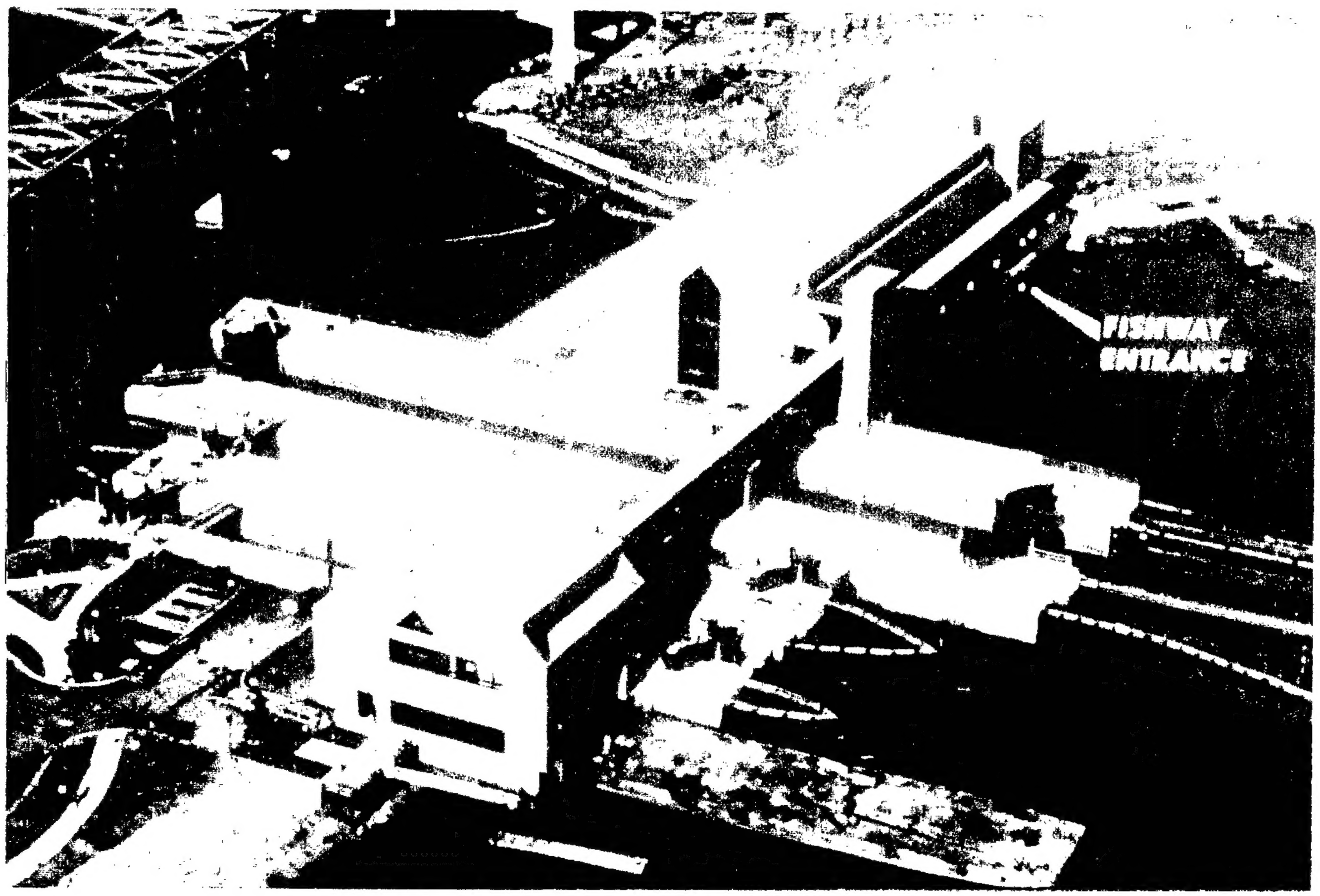
Feasibility
(Section 1135) Report
and
Environmental Assessment

Fish Passage Modification Charles River Dam Boston, Massachusetts



December 1992

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13. ABSTRACT *(Maximum 200 words)* The purpose of this study is to conduct a feasibility investigation of restoring upstream and downstream fish passage at the Charles River Dam, and to modify project structures and operations for the purpose of restoring fish passage to a modern historic condition. Fish passage at the dam occurs primarily through a fish ladder and navigation locks. However, fish passage through the ladder is reduced by damaged or missing equipment, ineffective maintenance, and debris accumulation throughout the facility, and the navigation locks are limited by the irregular and infrequent locking operations that occur during late winter and spring. This report examines alternatives to accomplish these goals and compares them to existing conditions. However, the MDC does not endorse full restoration of the fish ladder nor the proposed formal protocol of locking fish. The investigation has determined that existing fish passage problems are primarily the result of ineffective maintenance of equipment and infrequent debris collection and disposal. This report recommends that Federal involvement to restore fish passage at the Charles River Dam under Section 1135 should not be continued.

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FISH PASSAGE MODIFICATION
CHARLES RIVER DAM
BOSTON, MASSACHUSETTS

FEASIBILITY
(SECTION 1135) REPORT
AND
ENVIRONMENTAL ASSESSMENT

U.S. Army Corps of Engineers
New England Division
December, 1992

EXECUTIVE SUMMARY

This study is an investigation of fish passage at the Charles River Dam, Boston, Massachusetts. Authorization for this study is provided under Section 1135 of the Water Resources Development Act of 1986 (PL 99-662). The purpose of the study is to determine the feasibility of Federal action, under the Section 1135 authority, to modify project structures and operations for the purpose of restoring fish passage to a modern historic condition. The Charles River Dam constructed by the US Army Corps of Engineers is operated and maintained by the Metropolitan District Commission (MDC), Commonwealth of Massachusetts.

The Charles River Dam is the gateway to the Charles River system. Fish passage at the dam occurs primarily through a fish ladder and navigation locks. The current state and operation of these facilities, however, infrequently provide effective conditions for fish passage. Effective fish passage through the ladder is reduced by damaged or missing equipment, ineffective maintenance, and debris accumulation throughout the facility. Fish passage opportunities at the navigation locks are limited by the irregular and infrequent locking operations that occur during late winter and spring. The most practical alternatives for restoring fish passage is to increase the frequency and regularity of operating the navigation locks and restoring the fish ladder.

This report examines alternatives to accomplish these goals and compares them to existing conditions. Alternatives consist of full or partial restoration of the fish ladder and operating the navigation locks under a formal protocol for fish locking. The examination indicates that restoring the fish ladder to operate throughout complete tidal cycles and implementing a formal protocol for fish locking would significantly improve the quality of fish passage at the existing Federal project.

However, the MDC does not endorse full restoration of the fish ladder nor the proposed formal protocol of locking fish. The MDC believes that more definitive environmental information is needed before full restoration should be advocated and that implementation of a formal protocol for locking fish would adversely impact pedestrian usage and safety issues.

The report concludes that Section 1135 of the Water Resources Development Act of 1986 is not an appropriate authority to restore fish passage at the facility. Section 1135 is designed to restore environmental degradation caused by projects constructed under the authority of the Secretary of the Army. The investigation has determined that existing fish passage problems are primarily the result of ineffective maintenance of equipment and infrequent debris collection and disposal.

This report recommends that Federal involvement to restore fish passage at the Charles River Dam under the Section 1135 authority should not be continued.

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STUDY AUTHORITY

Authority to perform this investigation is provided under Section 1135 of the Water Resources Development Act of 1986 (PL 99-662), as amended. Section 1135 entitled Project Modifications For Improvement Of Environment states, in part, ...

> "The Secretary is authorized to review the operation of water resources projects constructed by the Secretary before the date of enactment of this Act to determine the need for modification in the structures and operations of such projects for the purpose of improving the quality of the environment in the public interest."

Project eligibility includes criteria that (1) a project was constructed by the Secretary of the Army before 1986, (2) project modifications are consistent with authorized project purposes, and (3) a determination that environmental degradation resulted from construction of the initial project.

STUDY PURPOSE

The purpose of this study is to conduct a feasibility investigation of restoring upstream and downstream fish passage at the Charles River Dam, Boston, Massachusetts. The study examines options of structural and operational modifications that would restore fish passage at the project and considers project eligibility under Section 1135 authority.

STUDY SCOPE

This study examines the existing condition of fish passage facilities at the project, reasons leading to degradation of fish passage and project modification alternatives to restore fish passage. The range of project alternatives is limited to operational and structural modifications that maintain consistency with existing project purposes. Engineering, economic and environmental criteria of each alternative is compared to determine the most favorable alternative. A description of the engineering and design work scope, costs, environmental benefits and impacts are provided for the most favorable alternative.

COORDINATION

This study has been prepared by the U.S. Army Corps of Engineers, New England Division (Corps). Letters of correspondence and coordination are contained in Appendix A.

A 1991 Management Committee Conference of the Massachusetts Bay National Estuary Program identified the need for water quality improvements and fisheries habitat restoration in the Charles River watershed. Subsequent discussions between the Metropolitan District Commission (MDC) and the Corps focused on restoration of fish passage at the dam. The MDC formally requested that the Corps undertake such an investigation under Section 1135 of the Water Resources Development Act of 1986 in a letter dated March 21, 1991.

The study has been coordinated in cooperation with the following Federal and State agencies:

U.S. Fish and Wildlife Service

National Marine Fisheries Service

Massachusetts Division of Marine Fisheries

Massachusetts Metropolitan District Commission

Massachusetts Historical Commission

PROJECT HISTORY

In 1967, the Corps initiated a two phase study of the Charles River Watershed. One phase focused on the watershed as a whole with the purpose of investigating flood control, navigation, environmental preservation, aesthetics, recreation, water supply and pollution control. This phase led to the Charles River Natural Valley Storage Project that involved the identification and protection of wetland and floodplain areas within the 307 square mile watershed, Plate 1. Goals consisted of formulating a watershed development plan to serve as a guide for the best combined use of water and related land resources. The other phase, identified as the Charles River Dam Project, focused on flood protection in the Lower Charles River Watershed, an intensely developed urbanized area. Goals consisted of solving the immediate problem of flooding from rapid urban runoff in the lower watershed, Plate 2.

Natural Valley Storage Project

The Natural Valley Storage Project was authorized by the Water Resources Development Act of 1974. Federal funding was obtained to protect selected natural valley storage areas by acquisition in fee or preserved in their natural condition through easements restricting building and filling of wetlands. Acquisition and protection of wetlands was recognized not only as a flood preventative strategy, but also as a program to assure the

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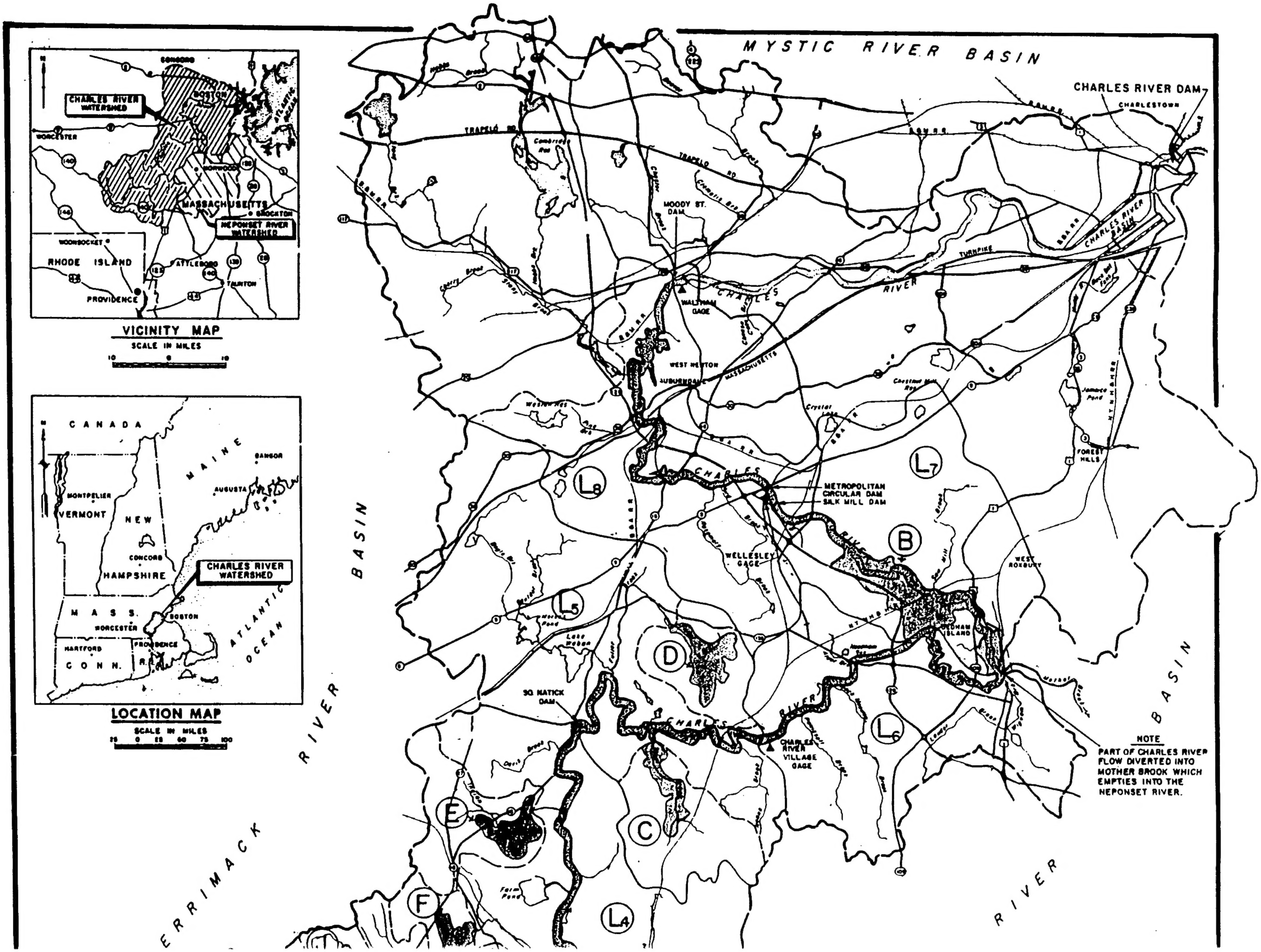


MYSTIC RIVER BASIN
CHARLES RIVER DAM
CHARLESTOWN
CHARLES RIVER BASIN
CHARLES RIVER
TURNPIKE
TRAPELO RD
MOODY ST. DAM
WALTHAM GAGE
WEST NEWTON
AUBURNDALE
MASSACHUSETTS
METROPOLITAN CIRCULAR DAM
SILK MILL DAM
WELLESLEY GAGE
DEDHAM ISLAND
WEST ROXBURY
FOREST HILLS
Jamaica Pond
SO. NATICK DAM
CHARLES RIVER VILLAGE GAGE
Lake Waban
Farm Pond
B
C
D
E
F
L4
L5
L6
L7
L8
NOTE
PART OF CHARLES RIVER FLOW DIVERTED INTO MOTHER BROOK WHICH EMPTIES INTO THE NEPONSET RIVER.
BASIN
RIVER
NEPONSET RIVER BASIN
MERRIMACK RIVER
VICINITY MAP
SCALE IN MILES
10 0 10
CHARLES RIVER WATERSHED
NEPONSET RIVER WATERSHED
BOSTON
WORCESTER
NORWOOD
MASSACHUSETTS
BROCKTON
WOONSOCKET
RHODE ISLAND
ATTLEBORO
TAUNTON
PROVIDENCE
LOCATION MAP
SCALE IN MILES
25 0 25 50 75 100
CANADA
MAINE
BANGOR
AUGUSTA
MONTPELIER
VERMONT
NEW HAMPSHIRE
CONCORD
MASS.
WORCESTER
BOSTON
HARTFORD
PROVIDENCE
CONN.
R.I.
ATLANTIC OCEAN

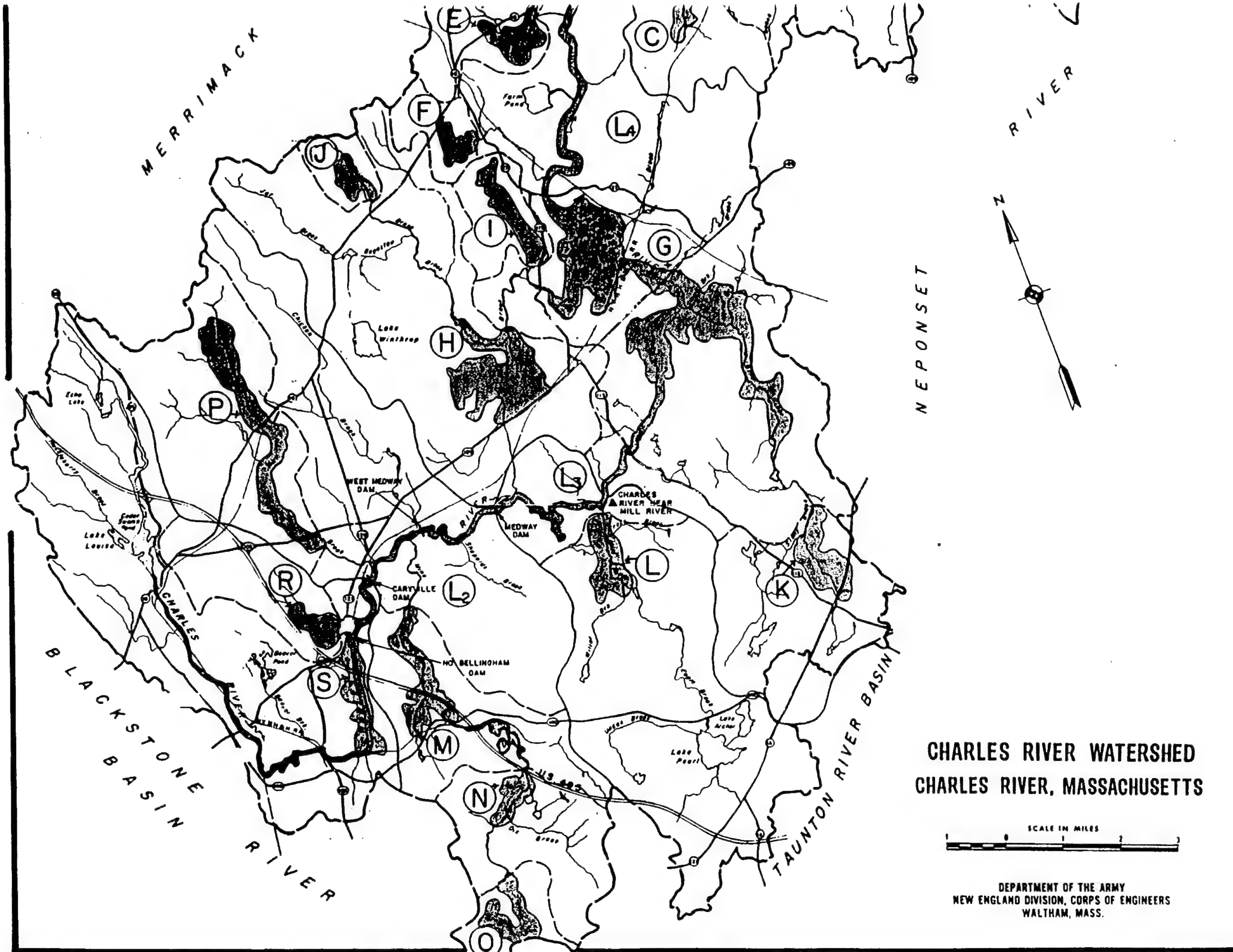
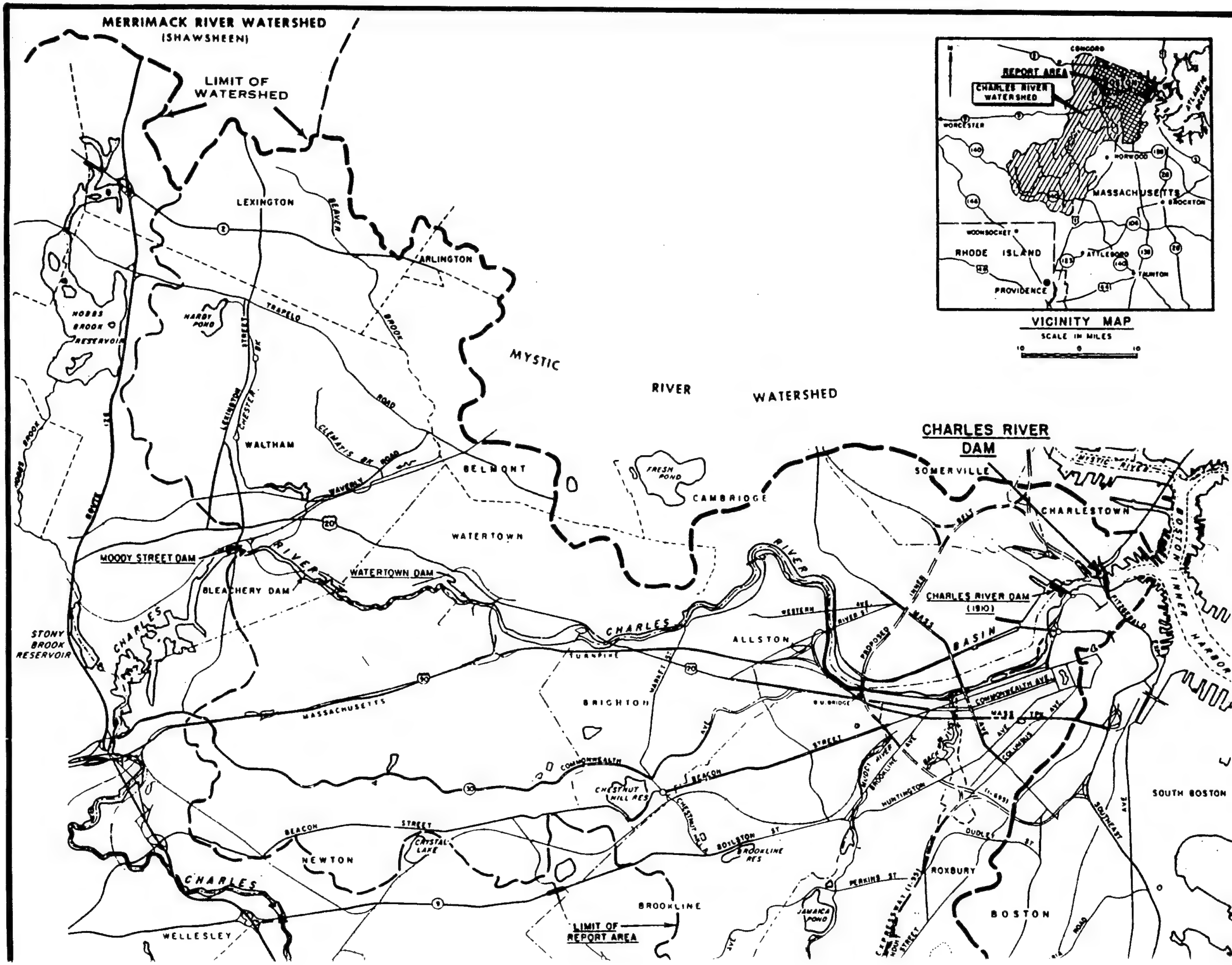
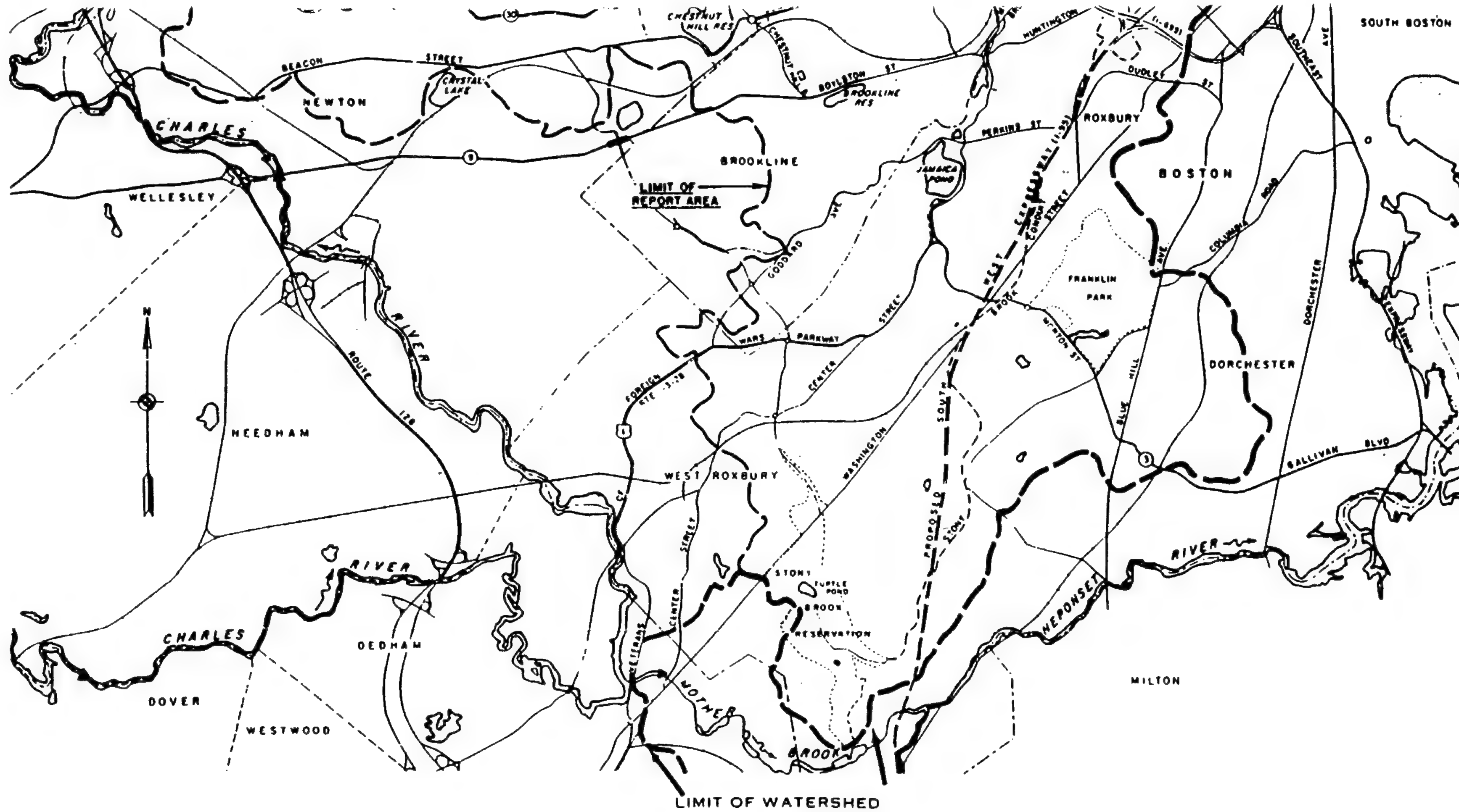

MERRIMACK
NEPONSET
RIVER
N
BLACKSTONE
BASIN
RIVER
TAUNTON RIVER BASIN
CHARLES
RIVER
E
C
F
L4
J
I
G
H
P
L3
CHARLES RIVER NEAR MILL RIVER
WEST MEDWAY DAM
MEDWAY DAM
L
K
R
CARYVILLE DAM
L2
NO BELLINGHAM DAM
S
M
N
O
Farm Pond
Lake Winthrop
Echo Lake
Lake Louisa
Lake Pearl
Lake Archer
US 1
CHARLES RIVER WATERSHED
CHARLES RIVER, MASSACHUSETTS
SCALE IN MILES
1
0
1
2
3
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE I

(2)


MERRIMACK RIVER WATERSHED
(SHAWSHEEN)
LIMIT OF WATERSHED
MYSTIC RIVER WATERSHED
CHARLES RIVER DAM
CHARLES RIVER DAM (1910)
MOODY STREET DAM
WATERTOWN DAM
BLEACHERY DAM
LIMIT OF REPORT AREA
STONY BROOK RESERVOIR
HOBBS BROOK RESERVOIR
HARDY POND
FRESH POND
CHESTNUT HILL RES
BROOKLINE RES
JAMAICA POND
CRYSTAL LAKE
LEXINGTON
ARLINGTON
WALTHAM
BELMONT
WATERTOWN
CAMBRIDGE
SOMERVILLE
CHARLESTOWN
ALLSTON
BRIGHTON
NEWTON
WELLESLEY
BROOKLINE
ROXBURY
BOSTON
SOUTH BOSTON
BOSTON INNER HARBOR
MYSTIC RIVER
CHARLES
RIVER
BASIN
COMMONWEALTH AVE
MASS TPK AVE
VICINITY MAP
SCALE IN MILES
REPORT AREA
CHARLES RIVER WATERSHED
MASSACHUSETTS
RHODE ISLAND
PROVIDENCE
WORCESTER
CONCORD
NORWOOD
BROCKTON
WOONSOCKET
ATTLEBORO
TAUNTON
ATLANTIC OCEAN

(1)



▲ U.S.G.S. STREAM GAGING STATIONS

LOWER CHARLES RIVER WATERSHED
CHARLES RIVER, MASSACHUSETTS

SCALE IN FEET

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 2

(2)

continued natural functions provided by wetlands. To date, approximately 8,100 acres of wetlands have been acquired by fee or easement and are managed as wildlife refuges with public access.

Charles River Dam Project

The Charles River Dam is located on the Charles River in Boston Massachusetts, Plate 3. The project consists of an earthen and concrete dam about 560 feet long, three navigation locks, a pumping station with six flood control pumps, two flood control sluiceways, and a fish passage facility. Other features include a harbor patrol facility, a public walkway across the river, offices, and a visitors' center. The Charles River Dam is operated and maintained by the Metropolitan District Commission (MDC), Commonwealth of Massachusetts.

The Charles River Dam Project was authorized by the Flood Control Act of 13 August 1968 (PL 90-483). Project purposes included flood control, navigation, fish passage and recreation. The original dam, which was constructed in 1910 and located about 2,250 feet upstream, was decommissioned following completion of the new dam.

The dam forms a tidal barrier between Boston Inner Harbor and the Charles River. The impoundment upstream of the dam is known as the Charles River Basin. The Basin extends 8.6 miles upstream to the Watertown Dam. Water level of the Basin is maintained about +2.5 feet National Geodetic Vertical Datum (NGVD). Water levels in the harbor vary with the tides. When the water level is lower in the harbor than in the Basin, the two submerged flood control sluiceways are used to drain Basin waters (gravity drainage). Flow through both flood control sluiceways is regulated by 8 feet wide by 10 feet high sluice gates. Both sluiceways are located adjacent to the fish passage facility on the north side of the dam. When the water level is higher in the harbor than in the Basin, one or more flood control pumps may be used to drain Basin waters (pumped drainage). Each flood pump has a capacity to discharge 1,400 cubic feet per second (cfs) and the total capacity of all six pumps is 8,400 cfs. The flood control pumps are located near the middle of the dam. Only in cases of extreme or emergency conditions may the navigation locks be used to facilitate river drainage. The navigation locks are located on the southern side of the Dam.

Construction of the Dam was completed in 1978 at a total cost of $61.2 million.

PRIOR STUDIES

Federal Studies

Lower Charles River for Flood Control and Navigation. US Army Corps of Engineers, New England Division. May 1968.

This interim report summarized the first phase of the two phase study of the Charles River Watershed. The study focused on the Lower Charles River Watershed where the

threat of serious flooding was the greatest and the need for protection was most urgent. The report included recommendations leading to the authorization of the Charles River Dam Project.

Charles River, Massachusetts. US Army Corps of Engineers, New England Division. December, 1971.

This report and appendices summarized the second phase of the two phase study of the Charles River Watershed. The study focused on the Middle and Upper Charles River Watershed where urbanization and development was much less intense. The report included recommendations leading to Federal acquisition in fee or by easement major natural valley storage areas.

Final Environmental Impact Statement, Charles River Dam. US Army Corps of Engineers, New England Division. July 1973.

This report contained information concerning environmental impacts from the proposed construction and operation of the Charles River Dam.

Charles River Study, Massachusetts. US Army Corps of Engineers, New England Division. 1976

This report contained the Final Environmental Impact Statement of the Natural Valley Storage Project.

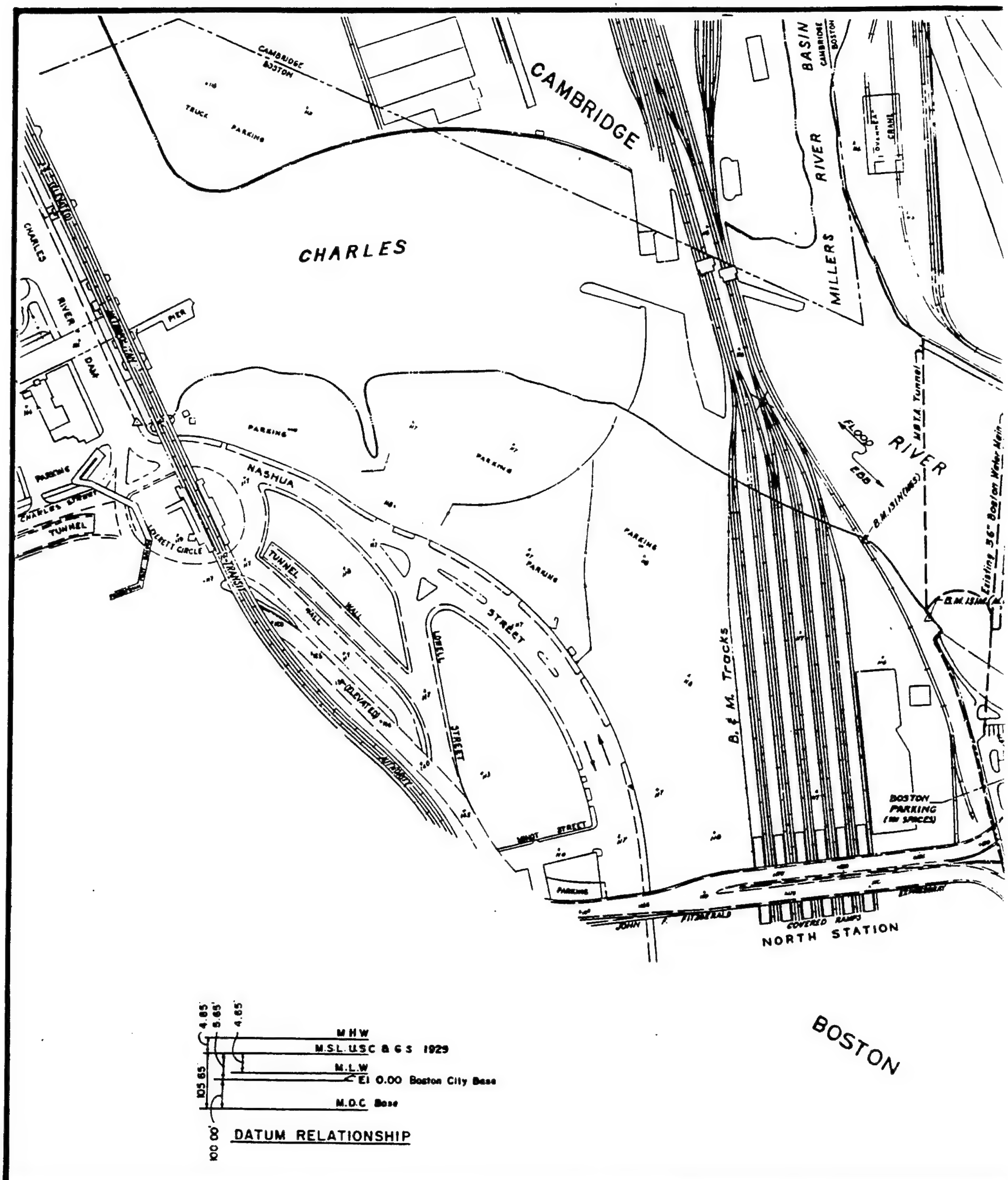
Fish Ladder For Charles River Dam, Technical Report No. 157-1. US Army Corps of Engineers, North Pacific Division. December, 1977.

This report summarized the hydraulic model investigation of the fish ladder for the Charles River Dam. Hydraulic model studies of the fish ladder were conducted at the North Pacific Division Hydraulic Laboratory, Bonneville, Oregon. The proposed design of the vertical-slot fish ladder was based on a successful ladder used to pass shad and other anadromous fish at John Day and Bonneville Dams on the Columbia River. The fish ladder was developed in cooperation with the Bureau of Sport Fisheries and Wildlife, the Division of Marine Fisheries of the Commonwealth of Massachusetts, and the US Fish and Wildlife Service.

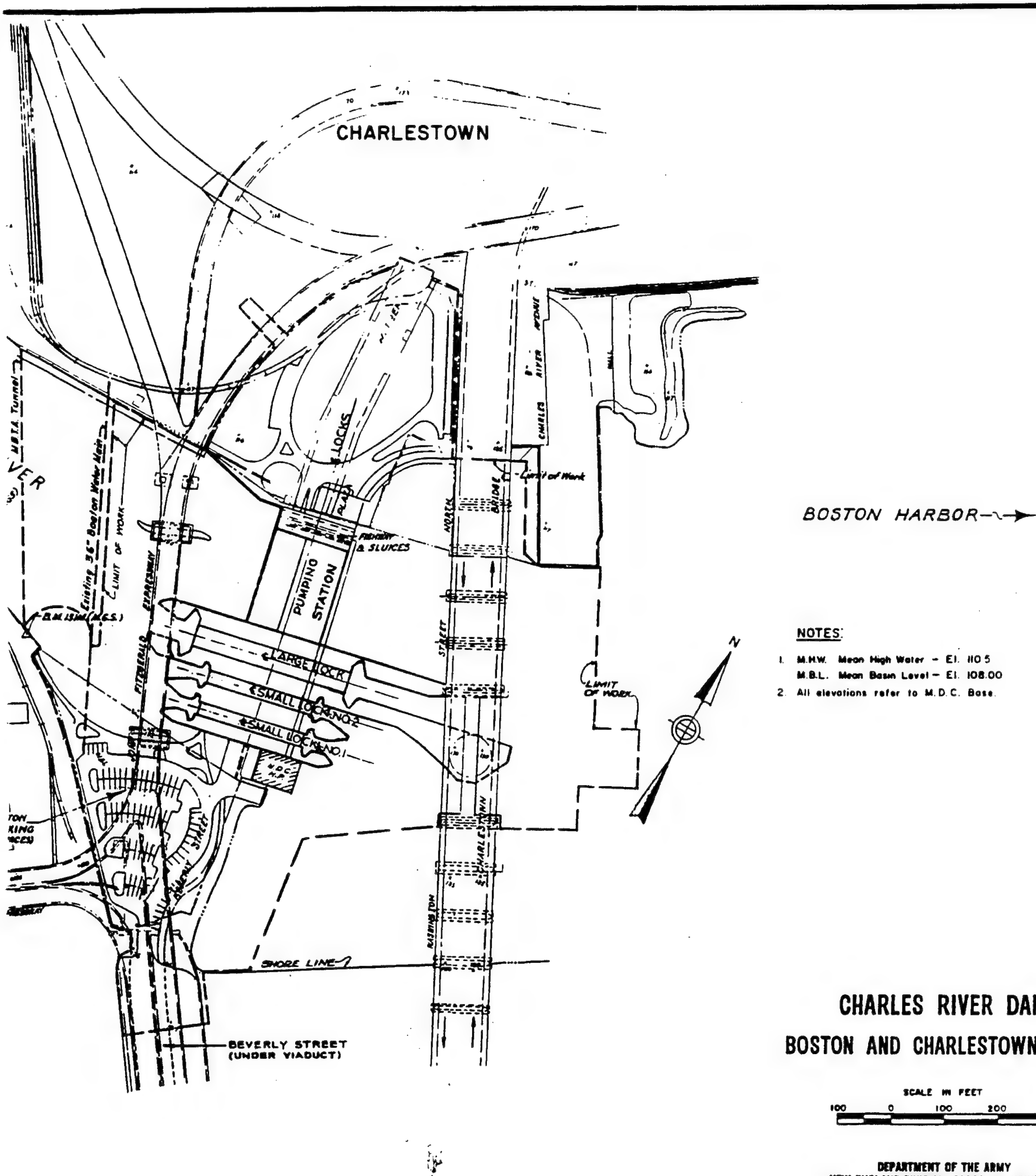
State Studies

Charles River Artificial Destratification Project. Metropolitan District Commission. June 1981.

This report describes the destratification system constructed in the Charles River Basin between the Watertown Dam (upstream) and Charles River Dam (downstream). A destratification system was initiated in 1978 to reduce nuisance conditions and fish kills


CAMBRIDGE
BOSTON
TRUCK
PARKING
CAMBRIDGE
BASIN
RIVER
MILLERS
CHARLES
CHARLES
RIVER
DAM
PIER
PARKING
NASHUA
STREET
TUNNEL
WALL
LOWELL
STREET
CHARLES STREET
TUNNEL
LEVERETT CIRCLE
MINOT STREET
PARKING
FLOOD
EBB
RIVER
MBTA Tunnel
Existing 36" Boston Water Main
B. & M. Tracks
BOSTON PARKING
COVERED RAMPS
JOHN F. FITZGERALD
NORTH STATION
BOSTON
MHW
M.S.L. USC & G S 1929
M.L.W
El 0.00 Boston City Base
M.D.C Base
4.85
5.65
4.85
105.65
100.00
DATUM RELATIONSHIP

(1)



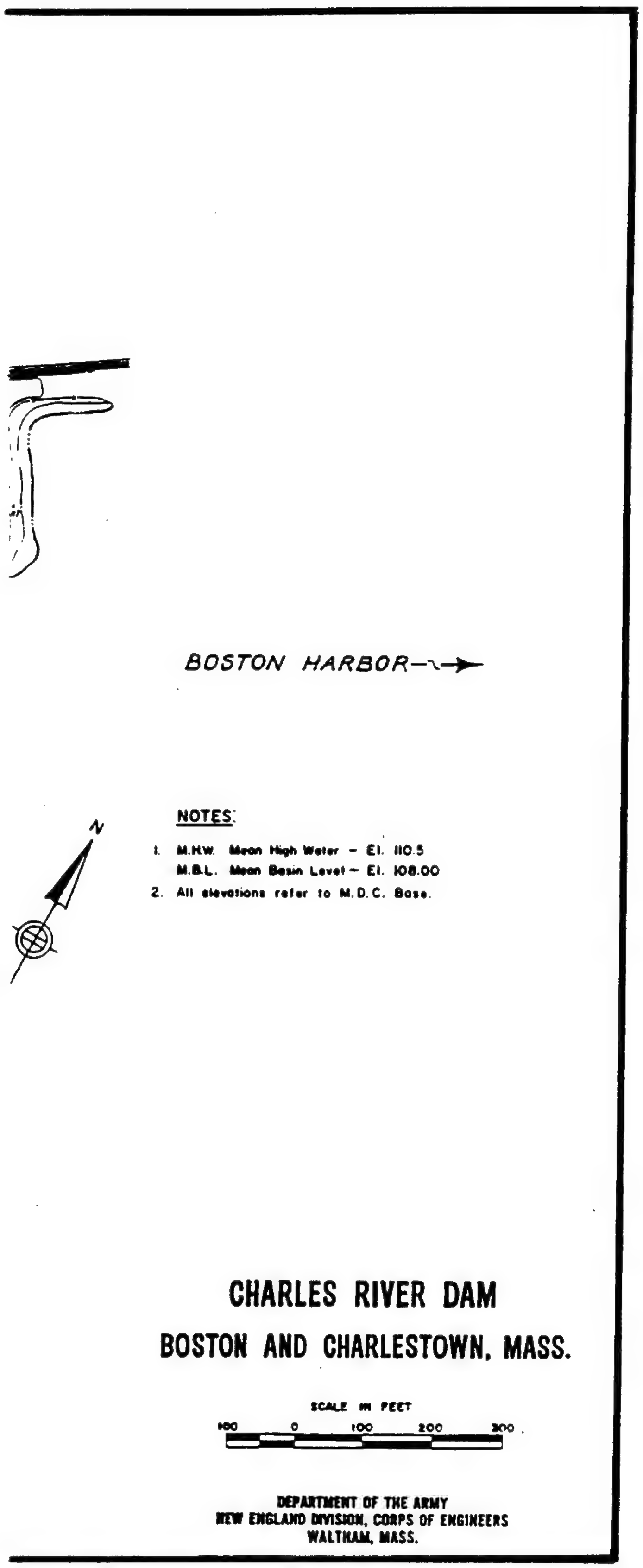
CHARLES RIVER DAM
BOSTON AND CHARLESTOWN, MASS.

SCALE IN FEET
100 0 100 200 300

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 3

2



CHARLES RIVER DAM

BOSTON AND CHARLESTOWN, MASS.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 3

3

caused by hydrogen sulfide from the anoxic bottom water. Six diffusers were installed in the deep sections of the Basin to induce sufficient circulation to provide oxygen throughout the water column. The report summarizes water quality changes during the period between September 1976 to December 1980.

Water Quality Survey Data, Charles River Basin. Massachusetts Division of Water Pollution Control. 1984.

This report contains water quality and sediment data for the Charles River Basin collected by the Massachusetts Division of Water Pollution Control. The report summarizes water quality data measured at several locations downstream of the Watertown dam and points out particular water quality concerns with dissolved oxygen, toxicants in the water column and sediments, and enteric pathogens.

SECTION II - EXISTING PROJECT DESIGN AND ENVIRONMENTAL SETTING

GENERAL

Potential fish passage routes at the project include a fish ladder, navigation locks and flood control sluiceways. The fish ladder and the navigation locks provide open channels to support both upstream and downstream migrations. The flood control sluiceways are submerged and probably assist downstream passage. The locks are located on the south side of the dam in a zone where waters are relatively calm. The fish ladder and flood control sluiceways are located on the north side of the dam in a zone where basin drainage occurs. Downstream flow is directed to this side of the river. Water quality in the basin varies with near surface waters of higher quality than waters in the lower water column.

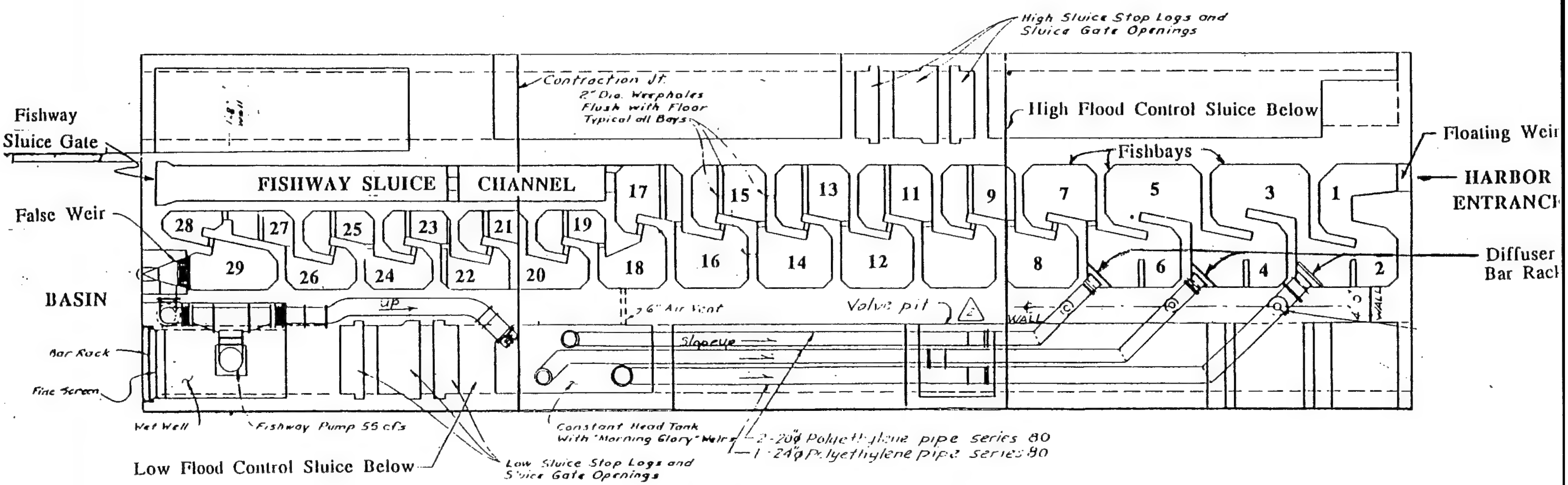
FISH LADDER

The existing fish ladder is shown in Plate 4. A floating weir is located at the harbor entrance. The weir moves in a vertical plane and maintains constant depth (between 2 and 3 feet) beneath the tide level. The purpose of the weir is to maintain effective discharge velocities into the harbor throughout a complete tidal cycle and thereby encourage fish to enter the facility during upstream passage events. The ladder contains 29 bays connected by vertical slots which are numbered 1 to 29.

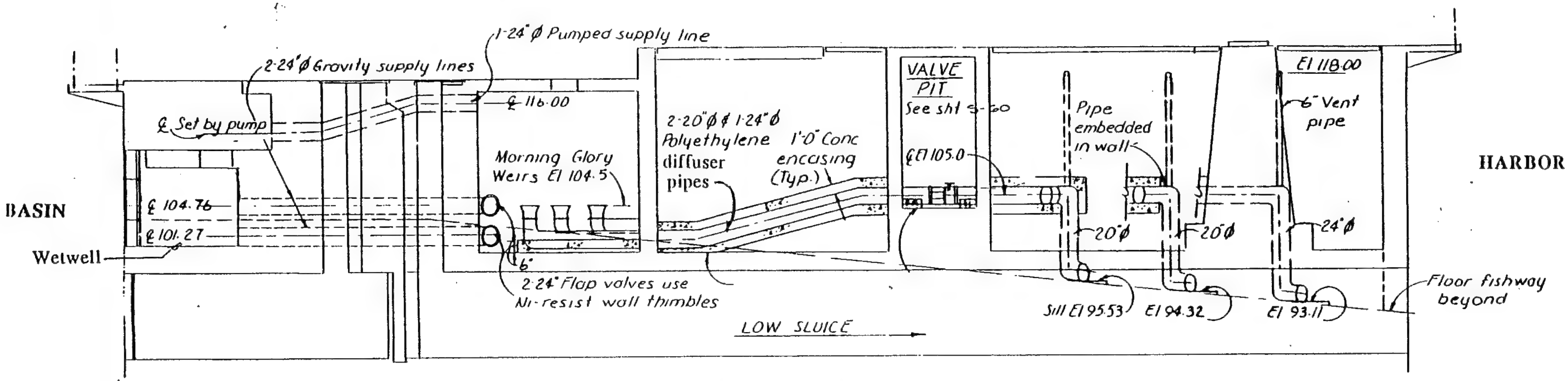
At the end of bay 17, a fishway sluice channel leads to the basin. When the water in the basin is higher than the harbor, water flows by gravity into the fishway sluice, through the lower 17 bays and into the harbor. During this condition, adults and juveniles can migrate downstream through the ladder system. At the end of bay 29, a false weir leads to the basin. When the basin is lower than the harbor, water is pumped into bay 29. A portion of this water returns to the basin through the false weir, and the remaining portion flows through all 29 bays and into the harbor. The fishway pump is located adjacent to bay 29. During this condition, fish moving downstream are prevented from entering the fish ladder.

Gravity supply piping, pump supply piping and diffuser piping are located adjacent and parallel to the bays. This piping system furnishes additional supply water to the lower bays. When the basin is higher than the harbor, water flows by gravity into the pumpwell, gravity supply piping, diffuser piping and lower fish bays. When the basin is lower than the harbor, water is pumped into the diffuser piping and lower fish bays.

The design of the fish ladder incorporates features to always discharge freshwater from the basin into the harbor. These features provide freshwater through the ladder to attract fish and prevent saltwater intrusion into the basin. Two modes of operation, gravity flow and pumped flow, have been designed to accomplish this purpose. Gravity flow occurs when the water level in the harbor is lower than the basin. Pumped flow occurs when the water level in the harbor is higher than the basin.



OVERALL LAYOUT OF HYDRAULIC SYSTEMS
WITH CONCRETE COVER REMOVED FOR VIEWING



HYDRAULIC PROFILE-PIPING

PLATE 4

CHARLES RIVER DAM
FISHWAY PLAN
AND PIPING PROFILE

Under the gravity flow mode of operation, the fishway sluice gate is opened. Basin water flows into the fishway sluice channel, enters the fish bays at bay 17 and into the lower fish bays. Additional basin water is introduced in the lower fish bays (bays 6, 4, and 2) from the diffuser pipes. Effective upstream fish passage conditions occur once the discharge velocity at the floating weir reaches or exceeds 4 feet per second (fps). Although the water level in the harbor is lower than the basin approximately 60% of a tide cycle, effective upstream fish passage conditions occur about 55% of the cycle. The time differential is necessary for attraction velocities to develop at the floating weir. Fish enter the basin via the fishway sluice gate opening. Downstream fish passage may occur anytime during the gravity flow mode of operation.

Under the pumped flow mode of operation, the fishway sluice gate is closed and basin water is pumped into bay 29 and into the diffuser pipes. A portion of the basin water is returned to the basin through the false weir and the remaining portion flows through all 29 fish bays. Additional basin water is introduced in the lower fish bays from the diffuser pipes. Effective upstream fish passage conditions occur throughout the pumped flow mode because discharge velocities always exceed 4 fps. The pumped flow mode is operated about 45% of the tide cycle. A portion of the water is returned to the basin through the false weir. Fish enter the basin via the false weir. Downstream fish passage is prevented during the pumped flow mode of operation because fish in the basin are prevented from entering the fish ladder system.

A more detailed description of the fish ladder is included in Appendix B, Hydraulic Analysis Fish Passage Facility.

NAVIGATION LOCKS

There are two small (recreational) navigation locks and one large (commercial) navigation lock at the dam. The small locks are each 200 feet long and 25 feet wide. The large lock is 300 feet long and 40 feet wide. Side channel culverts are used to fill and empty the locks. Lock gates are provided at the harbor and basin ends of each lock. In addition to navigation control, the locks may be used to assist fish migrations into and out of the basin and for basin drainage during emergency conditions.

Upon demand, all three navigation locks can be used for passing boats. The capacity of such an operation is estimated to be between 150 and 160 boats per hour in the demand direction. Boat locking records for 1989 and 1990 indicate that about 12,000 to 13,000 boat lockings occur annually. Normally, a locking event is typically accomplished in about five minutes. Seasonally, the number of boat locking events show considerable variation. In winter, lockings are fewer than one per day. In spring, lockings progressively increase from about one per day to several per day (see Environmental Assessment). In summer, lockings often exceed 100 per day. In autumn, lockings progressively decrease from several per day to a few per day.

The locks may be filled by gravity with water from either the basin or the harbor. When the basin level is higher than the harbor level, the locks are filled with fresh water from the basin; conversely, when the harbor level is higher than the basin level, the locks are filled with sea water from the harbor.

The locks are designed to always empty water into the harbor. During periods when the lock water level is higher than the harbor level, emptying is accomplished using gravity feed through a culvert system. During periods when the lock water level is lower than the harbor level, emptying is accomplished using the culvert and wetwell pumping systems.

The lock gates at the basin end also accommodate pedestrian traffic between Boston and Charlestown. The bulk of pedestrian traffic occurs during normal working hours. Peak daily usage is consistent with work commuter periods, and, moderate usage is experienced throughout the day. Occasionally, night usage is heavy, particularly when events are held at the nearby Boston Garden. Pedestrian traffic is delayed whenever a basin lock gate is opened. During a normal locking event of about five minutes, the basin lock gate is opened about two minutes. The delay is generally tolerated by pedestrians. However, longer delays occasionally result in vocal and written complaints.

Additional information concerning the navigation locks is included in Appendix B, Hydraulic Analysis Fish Passage Facility.

FLOOD CONTROL SLUICEWAYS

Two submerged flood control sluiceways are located adjacent to the fish ladder. The "high" flood control sluiceway is located north and immediately adjacent to the fish ladder; the "low" flood control sluiceway is located south and immediately adjacent to the fish ladder. Differences in sluice elevations allow releases from different parts of the water column in the basin. The submerged length of each sluiceway is 145 feet. The sluiceways are used to drain the basin during low tide conditions. Flow through each sluiceway is regulated by 8 feet wide by 10 feet high sluice gates. During moderate or high tide conditions, the sluice gates are closed to prevent harbor waters from entering the basin. Velocities in the sluiceways vary from about 0 to 14 feet per second (fps) depending on tidal conditions.

A more detailed description of the flood control sluiceways is included in Appendix B, Hydraulic Analysis of the Fish Passage Facility.

FISHERIES RESOURCES

Anadromous fish in the Charles River include rainbow smelt, alewife, blueback herring, and American shad. Atlantic salmon do not currently occur in the river, but may be the focus of restoration efforts in the future. Population estimates for anadromous fish are

not available for the Charles River. In general, runs of alewife and blueback herring have been good, and runs of shad have been very low in recent years. Smelt runs have declined in recent years which may reflect a general decline in southern Massachusetts or possibly conditions unique to the Charles River.

The spawning season varies among species, and from year to year depending mostly upon water temperature. Smelt migrations occur from mid-March until the end of April, primarily during the night. During daylight hours, smelt have a tendency to return to coastal waters. No information is available concerning depth preferences for smelt. Alewife and blueback herring runs occur from April to the end of May. Shad runs occur from mid-May through the end of June. Alewife, blueback herring and shad mostly migrate during the day and tend to use the upper water column.

Downstream migrations of juvenile fish in the Charles River occur from April through November. Juvenile smelt migrate downstream from April through late May. Juvenile alewife and blueback herring migrate from July through mid November. Juvenile shad migrate from October through early November. Juveniles are surface oriented, and are probably concentrated in the upper water column. Downstream migration can occur at any time of the day.

FISH PASSAGE

Alewife, blueback herring and shad are known to use the ladder during upstream migration, whereas smelt negotiate fish ladders poorly and few would utilize the ladder even if it were fully operational. It is not known why smelt do not respond well to fish ladders. However, Fish and Wildlife agencies have drawn this conclusion based on observations of other similar fish ladders.

Currently, most smelt, alewife, blueback herring, and shad probably access the basin through the navigation locks during normal boat locking events. Occasionally, lock operators will purposely lock fish when they observe large schools of fish in the harbor. Informal fish locking events are not recorded, so no data is available on the frequency or regularity of this practice. Although informal fish lockings are encouraged by Fish and Wildlife agencies, there have been no studies to determine its effectiveness.

Some upstream passage probably occurs through the flood control sluiceways. Actual passage through the sluiceways, however, may be quite limited for those species which migrate upstream during the day since they are probably reluctant to venture in the dark channels.

Downstream migration of juveniles probably pass through the fish ladder and the "high" flood control sluiceway during gravity flow conditions. Downstream passage may also occur through the navigation locks during boat locking events. However, the effective-

ness of locks to pass downstream juveniles is questionable since river flow occurs mostly on the opposite side of the dam. No information is available about the percentage of juveniles which successfully pass downstream of the dam. Although the condition of juveniles passing through the sluiceways is not known, some are probably injured by shear stress or abrasion during passage.

WATER QUALITY

The Charles River Dam is a tidal barrier to the river basin. Waters in the basin are classified as freshwater and waters in the harbor are seawater. Water quality classification of the basin is rated Class B by the Massachusetts Division of Water Pollution Control (MDWPC). Class B waters are designated an acceptable habitat for aquatic life and wildlife, and for primary and secondary contact recreation. Water quality in the harbor is rated class SB, and technical requirements for this class are similar to class B waters, but are saline.

Basin waters that are discharged through the facilities vary in water quality. Waters entering the fish ladder and high flood control sluiceway on the north side of the dam and the small southernmost lock are relatively good since these facilities draw from the upper part of the water column in the basin. The remaining locks and low flood control sluiceway draw waters from the mid to lower water column which are highly saline and contain sulfides.

The Water Quality Evaluation Charles River Basin in Appendix C includes a more detailed description of existing water quality conditions.

CULTURAL AND SOCIO-ECONOMIC RESOURCES

The Charles River Dam lies within the Charles River Basin Historic District, which is listed in the National Register of Historic Places. The District encompasses areas on both the north and south banks of the Charles River and extends west from the Charles River Dam to the Elliot Bridge.

The Charles River Basin offers several recreational opportunities to the millions of Boston residents. The Charles River Dam draws numerous visitors each year. There is considerable pedestrian traffic at the dam throughout each day and before and after events at the nearby Boston Garden. Thousands of boats pass through the dam locks each year with recreational traffic heaviest between mid May and late September.

SECTION III - PROBLEM IDENTIFICATION

RESOURCE PROBLEMS AND OPPORTUNITIES

Historically, the Charles River supported large runs of anadromous fish. American shad, alewife, blue back herring and smelt were well represented in the runs. During the period of growth and development of the metropolitan Boston area, these runs were significantly reduced by dams, pollution and habitat loss. Prior to the construction of the new Charles River Dam, fish migrations were mostly limited to alewife and smelt. These fish were able to gain access to the Charles River through navigation locks and flushing gates at the old dam.

During the past two decades, several measures have been taken to restore anadromous fish in the Charles River Watershed. These include construction of fish passage facilities at upstream dams and the re-introduction of American Shad into the basin.

The Charles River Dam is the gateway to the river system. Upstream and downstream migrations depend upon successful passage at the dam. Fish passage at the dam primarily occurs through a fish ladder and the navigation locks. The existing condition and operation of these facilities mostly limits opportunity for upstream fish passage. Debris accumulation and an inoperative floating weir in the fish ladder permit effective upstream fish passage only during low tide conditions. These conditions do not appear to have a significant impact on the existing capabilities of downstream fish passage. Upstream and downstream fish passage at the navigation locks is limited to times when boats are locked or when operators purposely lock fish. Boat lockings, however, are infrequent during early spring when upstream migrations are underway. Structural and operational modifications would provide a significant opportunity to restore effective upstream fish passage. The frequency and regularity of boat locking operations during the downstream migration periods provide a much greater opportunity for downstream fish passage. However, unless the navigation locks were to experience continuous sluicing, the effectiveness of locks to pass downstream juveniles is questionable since river flow occurs mostly on the opposite side of the dam.

PROBLEMS AND NEEDS

Fish Ladder

Construction of the Charles River Dam occurred in two phases. The initial phase consisted of constructing facilities, including the fish ladder system, on the Charlestown side of the river. The final phase consisted of constructing the navigation locks on the Boston side of the river. The two phase sequencing permitted flows to be diverted first to one side and then to the other side of the river.

Upon completion of the initial phase of construction, the MDC was to maintain the fish ladder system while the final phase of construction was undertaken. However, the fish ladder system was not effectively maintained during this period and the diffuser pipes became blocked by debris that accumulated during the final phase of construction. Initial field tests of the pumping mode of operation determined that the pipes were blocked. Efforts were made to clear the pipes using the fishway pump but were unsuccessful. Subsequent pumping trials conducted by the MDC led to motor burnout and eventual removal of the fishway pump. The nature and extent of pipe blockage was not determined during this period nor was the pump repaired or replaced. Since then, other components of the fish ladder including the floating weir, level sensors, and the pump wetwell screen have become inoperable or were removed and not repaired.

In general, debris collection and removal has not been regularly scheduled and efforts and equipment to remove debris have been ineffective. Occasionally, large objects such as railroad ties and tree stumps have been manually removed from the fishway bays, but normal cleaning and debris removal is not regularly scheduled. Currently, the floor of the fish ladder shows considerable silt buildup and some of the pipes contain debris.

To determine the extent of repairs needed to the fish ladder, the fish ladder was dewatered and inspected as part of this study. A description of these efforts and findings are included in Appendix D, Fish Passage Facility Inspection Report.

Navigation Locks

At present, the locks are operated for boat passage and occasionally for fish migration. However, saltwater intrusion from existing lock operations is still a problem in the Charles River Basin. Lock operations at high tide introduce the greatest amount of saltwater into the basin. During these operations, saltwater in the locks is not pumped back into the harbor as the system was designed to do. Instead, saltwater in the locks is discharged into the basin. The wet well is seldom used to pump lockwater in to the harbor, partly because the wetwell valves and pumps are in poor condition and costly to maintain. The proper use of the wetwell is an important step to reduce the intrusion of salttwater into the basin.

Fish Passage

Alewife, blueback herring and shad are known to use the ladder. However, smelt negotiate fish ladders poorly and few would utilize the ladder, even if it were fully operational. It is not known why smelt negotiate fish ladders poorly. This is a determination of Fish and Wildlife agencies and based on observations of smelt passage at other fish ladders.

Currently, effective upstream fish passage through the fish ladder is severely limited because the floating weir is damaged and the diffuser pipes are partially blocked. These conditions prevent attraction velocities at the harbor entrance until water levels in the

harbor fall to about Mean Spring Low Water (-5.2 feet NGVD). An evaluation of the existing conditions has determined that about 30 cumulative hours of effective passage time occur from April to the end of June. This evaluation is included in Appendix E, Fish Passage Hour Determinations.

Fish that enter the upper bays (leading to the false weir) become trapped because the absence of the fish pump prevents exit to the basin through the false weir. Apparently, fish are unable or unwilling to move back down from the upper bays and instead remain in place. Over a period of time, dissolved oxygen becomes depleted and fish kills occur, particularly when significant numbers of fish are trapped.

Currently, most smelt, alewife, blueback herring, and shad probably access the basin through the locks during normal boat locking operations. Because boat lockings are most infrequent during early spring, upstream smelt migrations benefit the least from normal boat locking events. To determine the cumulative passage time, a review of past locking events at the dam was made and compared to the migration season of each type of fish. Under existing conditions, approximately 1 to 2 hours of cumulative passage time is currently available for smelt to migrate upstream at the locks (mid March to the end of April). Approximately 25 to 40 hours of cumulative passage time is available for alewife and blueback herring to migrate upstream through the locks (April to the end of May), and about 45 to 50 hours is available for shad to migrate through the locks (mid May to the end of June), Appendix E, Fish Passage Hour Determinations.

Fish that are trapped in the locks following a boat locking procedure apparently survive the experience since there is no evidence of fish mortality occurrences.

Downstream fish passage appears to be less critical than upstream passage. There have not been reports of significant fish kills during downstream migration. Because river flows are directed to the fish ladder side of the dam, it is likely that most downstream passage occurs on this side of the dam. Under current operating conditions, the fish ladder already probably provides for passage of substantial numbers of juveniles during the gravity mode of operation. Although the effectiveness of locks to pass downstream juveniles is questionable, it is to be noted that boat lockings are more frequent during the downstream migration period. Further studies, however, are needed to confirm this and determine if additional measures using the locks to pass juveniles downstream are required.

Water Quality

Water quality in the Basin usually does not meet class B standards. The primary problem is a stratified layer of saltwater present in the basin. The denser saltwater resides below the lighter freshwater, forming a stratified layer or hypolimnium. This layer does not mix with the upper waters and becomes depleted of oxygen. Contributing to this oxygen deficit are highly organic oxygen demanding sediments originating from combined sewer

overflow discharges. Overall, the high salinity, low to zero dissolved oxygen, and presence of sulfides create an extremely toxic environment to aquatic life. This restricts habitat to the upper layers of the water column which is usually of fairly good quality.

Although beyond the scope of this study, water quality related impacts on fish and especially juveniles during passage through the basin is of concern. Existing lock operations at the dam introduce the greatest amounts of saltwater into the basin. Lock emptying procedures are seldom followed when the harbor level exceeds the basin level. Instead of using the wet well and pumping system to discharge lockwater into the harbor, lockwater is drained into the basin by gravity discharge.

Basin waters that are discharged through the facilities vary in water quality. Waters entering the fish ladder and high flood control sluiceway on the north side of the dam and the small southernmost lock are relatively good since these facilities draw from the upper part of the water column in the basin. The remaining locks and low flood control sluiceway draw waters from the mid to lower water column which are highly saline and contain sulfides.

An evaluation of water quality was performed as part of this study to determine the feasibility of various options to modify fish passage. The evaluation includes a review of existing information and collection of water quality data near the dam. The evaluation report is provided in Appendix C, Water Quality Evaluation Charles River Basin.

PROJECT CONDITIONS WITHOUT FEDERAL ACTION

Without proposed Federal actions, the opportunity for upstream fish passage will continue to be severely limited. Progress gained from improving upstream habitats and fish passage facilities elsewhere in the watershed may be impaired by inefficient upstream fish passage at the Charles River Dam. Also, fish kills will continue to occur in the fish ladder.

SECTION IV - FORMULATION OF ALTERNATIVES

DEVELOPMENT OF ALTERNATIVES

Initially, a wide range of alternatives were considered for evaluation. Objectives included the ability to alleviate existing project inefficiencies, responsiveness to opportunities, and acceptability to the sponsor, various agencies and public interests. During progress of the study, information obtained from agency coordination, field investigations and planning constraints were used to determine the viability of each alternative. Alternatives deemed not to be viable were excluded from further consideration. Remaining alternatives were evaluated for cost effectiveness based on costs and environmental restoration considerations.

ALTERNATIVES

1) No Federal action.

Without Federal action, the existing conditions at the Charles River Dam would likely remain unchanged. Substantial numbers of alewife and blueback herring and lesser numbers of shad and smelt will be able to migrate upstream.

Fish passage will occur mostly through the navigation locks. Continuation of informal fish locking procedures will support upstream migrations of alewife and blue back herring but will not significantly enhance migrations of smelt. Existing informal locking procedures are based on the ability of operators to observe activity in the harbor and the night time migration of smelt in the early season will be difficult to observe.

Passage through the fish ladder will be significantly limited due to the lack of sufficient attraction flow most of the time. Debris accumulation in the ladder will also limit fish passage. Occasionally, fish kills will occur in the fish ladder, particularly in the upper bays.

2) Decommission the existing fish ladder and develop a formal protocol for passing fish through the navigation locks.

Under this alternative, fish passage would be restricted to navigation locks and flood control sluiceways. A formal locking program would provide a greater opportunity for fish to move upstream at the south side of the dam. Decommissioning the fish ladder would eliminate upstream fish mortality in the fish ladder system. However, the high quality downstream passage of juveniles offered by the ladder would be lost.

In general, decommissioning the fish ladder would reduce fish passage opportunity and would not represent an environmental restoration action. Therefore, this alternative was

not given further consideration and methods and costs to decommission the fish ladder were not evaluated.

3) <u>Completely restore the fish passage facility to original design specifications and develop a formal protocol for passing fish through the navigation locks.</u>

Complete restoration of the fish passage facility includes reinstalling the fishway pump and repairing or replacing other components in the facility. The reinstallation of the fishway pump would permit fish to continually access the basin throughout each day as well as provide downstream passage during the gravity mode of operation. Additionally, the formal locking program would provide a greater opportunity for fish to move upstream at the south side of the dam.

4) <u>Completely restore the fish passage facility to original design specifications without developing a formal protocol for locking fish.</u>

With this alternative, the fishway pump would be installed to maximize fish ladder use and existing operational practices of the navigation locks would not be altered.

5) <u>Partially restore the fish passage facility and develop a formal protocol for passing fish through the navigation locks.</u>

Under this alternative the fish ladder would provide effective upstream passage conditions for about 55% of each tidal cycle. The fishway pump would not be installed but structural modifications would be made to the fish ladders to prevent entrapment in the upper bays and provide effective attraction velocity conditions during this period of the tidal cycle. A formal locking program would be developed to provide a greater opportunity for fish to move upstream at the south side of the dam.

6) <u>Partially restore the fish passage facility without developing a formal protocol for locking fish.</u>

This alternative would prevent entrapment in the upper bays and provide effective upstream passage conditions for about 55% of each tidal cycle. Existing operational practices of the navigation locks would not be altered.

7) <u>Construct a completely new fish passage facility using a different design.</u>

This alternative encompasses numerous options to replace or redesign existing fish passage facilities. Examples include installation of mechanical trapping and hauling equipment, new channel construction, and modifying fish ladder configuration and other structural components.

This alternative was not given further consideration since the ladder and locks currently available at the project site appear to be sufficient to handle migration needs. This viewpoint is shared by the US Fish and Wildlife Service and the Massachusetts Division of Marine Fisheries. Also, by law, the scope is limited to structural/operational modifications and by the required time frame to complete modifications under the Section 1135 Authority. New construction proposed under this alternative would likely exceed both limitations.

SECTION V - EVALUATION OF ALTERNATIVES

GENERAL

To determine the most preferred alternative, passage times and costs of viable alternatives were evaluated and compared to existing conditions. Separate evaluations were made for the fish ladder and lock usage options. The results of each evaluation were combined to determine the most appropriate alternative. Because project costs were primarily associated with the fish ladder, an incremental analysis of effective passage time and costs was used as a basis for comparison. Units of passage time were expressed in hours to represent the cumulative time of upstream migration opportunity that would be available during an annual migration season. An analysis of passage times is shown in Appendix E, Fish Passage Hour Determinations. Other relative fish passage factors of fish ladder options were considered but not included in the incremental analysis since these factors are non-quantitative. Project costs are shown in Table 1 and based on information included in Appendix D, Inspection Report Fish Passage Facility.

FISH LADDER

An incremental analysis of the fish ladder was performed to compare options of 1) No Action, 2) Partial Restoration and 3) Full Restoration. Annual costs of the No Action option were estimated based on information provided by the MDC. Annual cost of Partial Restoration and Full Restoration were prepared based on field inspections and are shown in Table 1. An interest rate of 8 1/2 % and a project life of 100 years was used for amortization.

The incremental analysis of fish ladder options is shown in Table 2. Passage time refers to the cumulative time available for fish to migrate upstream during the migration season. Time increment refers to the difference in cumulative passage time between options. Annual Cost is the estimated yearly cost corresponding to each option and Cost Increment is the difference in cost between options. Cost is determined by dividing the Annual Cost by Passage Time. Incremental Cost is determined by dividing the Cost Increment by the Time Increment.

Under existing conditions, the upstream passage time is about 30 hours. Passage time is minimal since the defective floating weir prevents the development of attraction velocities at the harbor entrance, except at very low tides. Passage time represents the cumulative time of opportunity that occurs during daylight hours from April to the end of June. With partial restoration, the passage time increases to 700 hours. Passage time is based on the occurrence of attraction velocities at the entrance during the gravity mode of operation. Passage time under this option occurs over about 55% of the tidal cycle. Full restoration results in 1,300 hours of cumulative passage time. Passage time under this option occurs throughout each day and is independent of tidal conditions.

TABLE 1
PROJECT COSTS OF FISH LADDER OPTIONS

Project Costs	Full Restoration	Partial Restoration
Construction Costs		
Restoration	$177,000	$63,000
Contingencies	44,000	15,000
Plan. Engin. & Design	40,000	30,000
Constr. Management	27,000	10,000
SUBTOTAL	$288,000	$118,000
Monitoring	30,000	30,000
TOTAL FIRST COST	$318,000	$148,000
IDC (8 1/2% for one year)	$13,000	$6,000
TOTAL INVESTMENT	$331,000	$154,000
Annual Costs		
Interest & Amortization (8 1/2% for 100 years)	$28,000	$13,000
Operation and Maint.	45,000	31,000
Replacements*	5,000	3,000
TOTAL ANNUAL CHARGES	$78,000	$47,000

*Under full restoration:

First Cost of about $ 6,000 (i.e. stainless steel screens) to be replaced every 5 years.

First Cost of about $ 20,000 (i.e. log boom) to be replaced every 10 years.

First Cost of about $169,000 (i.e.pump, pump motor, pump and gate controls, floating weir, slots and guides) to be replaced every 25 years.

*Under partial restoration:

First Cost of about $ 6,000(i.e. stainless steel screens) to be replaced every 5 years.

First Cost of about $ 20,000 (i.e. log boom) to be replaced every 10 years.

First Cost of about $ 25,000 (i.e. floating weir, slots and guides) to be replaced every 25 years.

TABLE 2
INCREMENTAL ANALYSIS OF FISH LADDER OPTIONS

Option	Passage Time (Hrs)	Time Increment (Hrs)	Annual Cost	Cost Increment	Cost	Incremental Cost
No Action	30	N/A	$2,000	N/A	$67/Hr	
Partial Restoration	700	670	$47,000	$45,000	$67/Hr	$67/Hr
Full Restoration	1,300	600	$78,000	$31,000	$60/Hr	$52/Hr

Examination of Table 2 indicates that full restoration of the fish ladder is the most favorable. The ratio of annual costs to passage time (i.e. an expenditure of $60 for each hour of passage) is the most cost effective option. The other two options have the same ratios of $67 for each hour of passage time. Examination of incremental cost further supports full restoration. The annual expenditure of $31,000 to achieve full restoration increases the passage time by 600 hours at an incremental cost of $52/hr. Whereas, the annual expenditure of $45,000 to achieve partial restoration increases the passage time by 670 hours at an incremental cost of $67/hr.

In addition to costs and passage hours, non-quantitative fish passage factors were considered in the evaluation. These factors included mortality within the ladder, delay at the dam prior to passage, and passage of downstream migrating juveniles and adults.

Occasionally, significant numbers of fish have been asphyxiated in the fish bays following closure of the fishway sluice gate. Most of these losses occurred within the upper fish bays. With partial restoration, a permanent barrier would be installed between bay 17 and 18 to block access to the upper bays to eliminate entrapment potential. With full restoration, a barrier would be installed between bay 17 and 18 to prevent fish from entering the upper bays when the pump was not operating. Additional pumping could be done whenever large schools of fish are caught in the upper 12 bays during low tide. Thus, full or partial operation would reduce entrapment potential compared to the No Action option.

Delays to upstream migrations are currently experienced at the project site. Long delays at the dam caused by inadequate fish passage facilities may discourage some fish from migrating upstream. Delays also subject fish to an increased risk of predation and increased physiological stress.

Although delays would occur with all options, the full restoration option would result in the least amount of delay. With partial restoration, delays would occur during high tide

conditions. With full restoration, delays would be further reduced since the system would operate independently of tidal conditions.

Existing patterns of downstream migrations by adults and juveniles will not be appreciably changed by the choice of any option. Downstream movement is dependent upon the tidal cycle and independent of the fishway pump. Hydraulic avenues for downstream migration consist of the fish ladder and the flood control sluiceways. These avenues are only operable during mid and low tide conditions when the basin elevation is equal to or greater than the harbor elevation.

Based on these factors and the results of the incremental analysis, full restoration of the fish ladder has been evaluated to be the most preferred improvement option.

NAVIGATION LOCKS

Estimates of upstream fish passage time at the navigation locks are shown in Table 3. Two options of navigation lock usage were evaluated. One option consisted of maintaining existing practices; the other option consisted of implementing a formal protocol for fish locking. Separate determinations of fish passage time were made for smelt, alewife and blueback herring, and shad because of their distinct migration characteristics. Fish passage times in Table 3 do not include fish passage times of informal fish lockings since that data is not available. However, both options include continuation of informal fish lockings at the discretion of operators.

Under existing conditions, locking affords very little passage time for smelt. Smelt are the earliest to migrate into the river and migrate primarily at night. For purposes of evaluation, smelt are considered to migrate anytime between March 15 and April 30 each year. Boat lockings during this period are infrequent and irregular and it is estimated that only 1 to 2 hours of passage opportunity are available for smelt to migrate upstream. Alewife and blueback herring migrate between April 1 and May 31 each year with blueback herring tending to migrate somewhat later than alewife. Boat lockings in early April are infrequent and irregular but intensify throughout late April and May. It is estimated that about 25 to 40 hours of passage opportunity are available for these species to migrate past the dam during this two month period. Shad migrate between May 15 and June 30. By this time boat locking procedures are frequent and regular and about 45 to 50 hours of passage opportunity are available for shad to migrate past the dam.

Under formal locking protocol conditions, smelt would benefit the most with upstream passage time increasing to about 55 hours. Alewife and blue back herring migrations would also substantially benefit, with passage time increasing to about 75 hours. Increased passage opportunities would occur mostly during the early part of the migration season. Potential upstream passage time for shad would increase to about 55 hours.

The formal protocol for locking fish is described in the section entitled Selection of Alternative. The protocol was developed based on engineering, operations and maintenance, hydraulic, and water quality and fish and wildlife considerations. As many as seven additional lockings may be necessary in each 12 hour period throughout the migration seasons. The need to lock for fish, however, would be offset by normal boat locking events, especially from mid-spring to early summer. It is estimated that 400 additional locking events may be required each year with about 250 in March, 100 in April, 40 in May and 10 in June. Since lock operators are at the site 24 hours each day, 7 days each week, the costs corresponding to formal protocol would mostly be associated with additional wear and tear of lock gates. It is estimated that increased operational cost would be about $2,000 each year.

With consideration to fish passage improvement and project costs, a formal program to lock fish is judged to be the preferred option.

TABLE 3
FISH PASSAGE AT THE NAVIGATION LOCKS

Locking Procedure Option	Smelt Passage (Hrs)	Alewife and Blueback Herring Passage (Hrs)	Shad Passage (Hrs)
Existing	1 - 2	25 - 40	45 - 50
Formal	55	75	55

SECTION VI - SELECTION OF ALTERNATIVE

DESCRIPTION

The goal of evaluating alternatives is to determine the most favorable approach to restore fish passage opportunity at the Charles River Dam. The alternative selected to be most favorable consists of restoring the fish ladder to original design conditions and implementing a formal protocol for passing fish through the navigation locks.

Fish Ladder

Restoration of the fish ladder includes repairing and reinstalling the fishway pump, improving debris control practices, and making minor repairs and modifications to other components. Repairs to the existing fishway pump would consist of rebuilding pump components, replacing the motor, and replacing automatic gate and pump level controls. Minor repairs to other components would include, sealing and reinstalling the floating weir, reinstalling stop log guides and installing a barrier between fish bay 17 and 18. Improving debris control components would include installing a new screen at the pumpwell, cleaning the trash rack and diffuser gratings and replacing the existing log boom. Detailed descriptions of these actions and costs are included in Appendix D, Inspection Report Fish Passage Facility. Frequent periodic cleaning and debris removal activities would also be necessary.

The fish ladder would be operated using gravity and pumping modes from about 1 April to 30 June each year. Operation would be continuous during daylight hours. The screen to the pumpwell would be cleaned twice each day or as required and debris removal would be scheduled about once each week. The ladder would continue to be operated using the gravity mode until at least 15 November in order to provide downstream migration passage. An annual inspection and maintenance program would be performed between the period of 15 November and 1 April. This program would include dewatering the facility, cleaning silt and debris from the wet well, constant head tank and fish bays, jet cleaning the pipes and repairing other facility components as needed.

Navigation locks

A formal fish locking protocol would be implemented from about 15 March to 30 June each year. The southern-most recreational boating lock would be used whenever possible. The water quality investigation indicates that this lock draws basin water of acceptable quality for aquatic habitat. Use of the other recreational lock and commercial lock is not advisable due to poorer water quality. An upstream fish locking procedure would consist of 1) adjusting lock water level to harbor level, 2) opening the harbor lock gates for about a 30 minute period, 3) adjusting lock water level to basin level, and 4) opening the basin gates for about a 10 minute period.

The specified time periods for gate openings (i.e. 30 minutes for harbor gates and 10 minutes for basin gates) are based on existing practices by the MDC. It is reported that these gate opening periods appear to be adequate to allow fish to enter and exit the locks.

Formal fish locking procedures would be limited to periods when the harbor elevation is less than the basin elevation. Exceptions to this period would be permitted 1) based on information provided by the Massachusetts Division of Marine Fisheries 2) at times when peak runs are observed by lock operators to be underway and 3) once each day from 15 March to 30 April to permit downstream passage of smelt.

Limited changes to the procedures would be permitted to accommodate pedestrian traffic. Normal boat locking events would suffice as an hourly fish locking procedure providing that these events occur regularly throughout the hour.

Formal locking procedures would be implemented based on anticipated upstream migration of fish as delineated below:

SMELT

Nighttime locking from 15 March to 30 April. Locking procedures to be repeated approximately once each hour when the water level in the harbor is lower than the water level in the basin.

Daytime locking from 15 March to 30 April. A single downstream locking procedure to be made during the period when the water level in the harbor is higher than the water level in the basin.

ALEWIFE AND BLUE BACK HERRING

Daytime locking from 1 April to 31 May. Locking procedures to be repeated once each hour when the water level in the harbor is lower than the water level in the basin.

SHAD

Daytime locking from 15 May to 30 June. Locking procedures to be repeated once each hour when the water level in the harbor is lower than the water level in the basin.

SCHEDULE FOR ACCOMPLISHMENT

Approximately eighteen months is estimated to complete restoration of the fish ladder. The repair and reinstallation of the fishway pump will be the most critical element to impact the construction schedule. All other construction activities should be able to be accomplished while waiting for pump and motor repair. Five months will be required to complete plans and specifications and contract award. About three months will be necessary to

complete the shop drawing cycle, eight months to fabricate/repair the pump and motor and two months for installation and testing. Factors that could extend the estimated schedule include poor weather, construction restrictions during the migration season, and MDC required flood control activities.

The formal locking protocol should be implemented immediately.

EVALUATION REPORT

After the construction period is completed, a field study would need to be conducted during the next spring migration period. Monitoring would consist of capturing fish from Boston Harbor. Fish passage at the dam would be monitored using radio tagged smelt and alewife. The program would be designed to determine the following information:

a) the relative number of fish passing through the locks, fish ladder and sluiceways.

b) length of delay imposed by the dam on upstream migrants.

c) adequacy of the locking protocol.

An evaluation report would be prepared following field studies and be published by about 30 August in the same year following completion of modifications to the facility.

CONSISTENCY WITH PURPOSE

The Charles River Dam is a multi-purpose project, designed primarily for flood control and navigation. The restoration of fish passage opportunities would not impact these primary purposes.

EXPECTED ENVIRONMENTAL CHANGES

The proposed modifications would restore opportunity for upstream passage of anadromous fish at the Charles River Dam. Repair of the fishway would greatly increase passage opportunity for alewife, blueback herring, and shad. Fish mortality would also be expected to decrease at the ladder. The formal locking protocol would greatly increase passage opportunity for smelt, and to a lesser extent alewife, blueback herring, and shad.

Saltwater intrusion would be expected to increase as a result of additional fish locking actions. These increases would be limited to times when smelt are locked downstream during daylight hours in early spring and during times when additional lockings are done by operators. Otherwise, scheduled fish locking events should not significantly impact saltwa-

ter intrusion in the basin since these actions would occur when harbor levels are below basin levels and lockwater would be emptied into the harbor.

Some delays to pedestrian traffic crossing the dam would result from the increased locking operations during the spring season.

COSTS

Presupposing that modifications could qualify under the Section 1135 program, the first costs and cost sharing is shown in Table 4. The project first costs for the selected modification are estimated to be $588,000.

TABLE 4
SUMMARY OF PROJECT FIRST COSTS AND COST SHARING ALLOCATION

Item	Federal	Non-Federal	Total
Feasibility Study	$202,500	$67,500	$270,000
Restoration of Fish Ladder with contingencies	165,750	55,250	221,000
Plan., Engin. and Design	30,000	10,000	40,000
Construction Management	20,250	6,750	27,000
Monitoring Program	22,500	7,500	30,000
TOTALS	$441,000	$147,000	$588,000

Annual operation and maintenance costs are estimated to be $47,300 and consist of $2,000 for the navigation locks and $45,300 for the fish ladder. Operation and maintenance costs for the fish ladder consist of 1) energy and daily screen cleaning costs for the fish pump ($ 14,100), 2) annual cleaning of the facility ($ 18,500), and 3) weekly or periodic collection and removal of debris ($12,700). Operation and maintenance costs would be the responsibility of the Metropolitan District Commission.

BENEFITS

No population estimates for anadromous species are available for the Charles River. Also, the percentage of adult and juvenile fish which pass the dam is unknown. Therefore, benefits corresponding to numbers of fish cannot be determined. Instead, nonmonetary

environmental benefits are determined by considering the number of effective hours available for fish to pass the dam.

Full restoration of the fish ladder would increase the opportunity for alewife, blue back herring and shad to pass the dam. During the upstream migration season, effective fish passage time would increase from about 30 hours to 1300 hours. Also, the quality of fish passage would significantly improve since water flow in the ladder would be continuous each day over all tidal levels. Fish mortality in the ladders would decrease.

A formal protocol for fish lockings would primarily benefit smelt, but would also benefit alewife, blueback herring and shad. For smelt, the effective fish passage time would increase from about 2 hours to 55 hours between March 15 and April 30. The effective fish passage time for alewife and blueback herring would increase from between 25 and 40 hours to about 75 hours between April 1 and May 30. The effective fish passage time for shad would increase from about 50 hours to 55 hours between May 15 and June 30.

There would not be any monetary benefits derived from operational costs because the selected modification would result in increased operational costs of the fish ladder and navigation locks.

REAL ESTATE INTERESTS

Project modifications would be accomplished within existing project boundaries.

VIEW OF SPONSOR

Upon completion of a Draft Feasibility (Section 1135) Report and Environmental Assessment, a meeting was held between the MDC and the Corps of Engineers to review report findings and request comments from the MDC. Written comments received from the MDC following the meeting are included in Appendix A. In general, the MDC does not endorse full restoration of the fish ladder nor the proposed formal protocol of locking fish. The MDC believes that more definitive environmental information is needed before full restoration should be advocated and that implementation of a formal protocol for locking fish would adversely impact pedestrian usage and safety issues.

Fish Ladder

The MDC does not endorse full restoration of the fish ladder. The MDC considers that the need for full restoration has not been fully demonstrated by this study. Several questions remain unanswered concerning population counts, migratory behavior, etc., and that the

study evaluation which is based on hours of fish passage is insufficient to justify expenditure for full restoration. Furthermore, the MDC believes that the reliability of the pump mode of operation has not been proven. This viewpoint is based on the facts that the fish ladder system has never operated as designed and repeated attempts to overcome difficulties have not been successful.

The MDC believes that, at this time, partial restoration would be in their best interest. The MDC considers that partial restoration in combination with a study to monitor migrant fish populations would be an effective method to determine the need for full restoration. This approach would reduce capital outlay in refurbishing the fish ladder system and acquire additional information from a monitoring program that would better define fish passage needs.

Navigation Locks

The MDC does not support the formal locking protocol as defined in this study but requests refinement to the proposed protocol. The MDC is concerned with times necessary for lock openings, especially at the basin side lock. Significant safety problems are reported to exist with the pedestrian walkway and past experience with commuter pedestrian traffic indicate that delays of 10 minutes each hour would be unacceptable to the public. The MDC contends that the walkway is heavily travelled by people commuting back and forth between Boston and Charlestown. The MDC also requests that consideration be given to upgrading the safety features especially for the suggested nighttime fish locking operations. The MDC is less concerned with the proposed openings at the harbor side lock. In fact, the MDC has indicated that the 30 minutes allocated for harbor side lock openings have been exercised in the past with satisfactory fish entrance results.

Instead, the MDC would prefer more of an informal locking program at the discretion of lock operators during daytime and a reduced time to conduct formal locking at nighttime. The daytime informal locking program would permit greater flexibility to accommodate pedestrian traffic and minimize public complaint. The nighttime formal locking program is not favored since significant safety issues exist with nighttime pedestrian traffic. The MDC believes that reduced nighttime locking requirements could be realized from information that could be obtained by a study to monitor migrant fish populations.

SECTION VII - APPLICATION OF SECTION 1135 AUTHORITY

To the extent that degradation of the quality of the environment has been caused by a Corps project constructed before 1986, Section 1135 of the Water Resources Development Act of 1986 may be used as an authority to restore loss of quality. Inherent to this action is the need to demonstrate that degradation has been caused by project development. Once demonstrated, modifications to structures or operation of the project may be cost shared with Federal funds under the Section 1135 authority. Otherwise, funding authorities other than those of Section 1135 would need to be obtained to carry out restoration actions.

Authority to perform a Section 1135 study at the Charles River Dam has been based on both the recognition of fish passage concerns and a willingness by the MDC to work with the Corps to seek resolution to these concerns. However, before proceeding into the engineering and modification phases of restoration using Section 1135 funds, it becomes necessary to determine reasons as to why degradation has occurred. Subsequently, a review has been made of those project components found to be in need of repair or replacement. Components include the fishway pump and motor, piping, floating weir, dewatering accessories, concrete and structural features, navigation locks, wetwell system, and pedestrian gates. The review has been based on information obtained from field inspections, the Operations and Maintenance Manual, historic documents and semi-annual Corps inspection reports of the project.

FISH LADDER

Construction of the Charles River Dam incorporated fish passage by installing a fish ladder system. The fish ladder was based on a model study of the original fishway design conducted by the North Pacific Division Hydraulic Laboratory in Bonneville, Oregon, in coordination with the U.S. Fish and Wildlife Service (Appendix B). Results of the model study demonstrated that the gravity mode and pump mode of operation should function as designed.

Existing difficulties with the pump mode of operation have been primarily the result of debris entering the system. This determination is based on information obtained from field inspections conducted during November and December in 1991 and review of semi-annual inspection reports. Field inspections found that diffuser pipes, fish bays, and openings between bays were partially or fully blocked, and the constant head tank and wet well to the fish pump were laden with debris. Semi-annual inspection reports written between 1982 and 1985 also record problems due to debris accumulation.

The semi-annual inspection reports also include discussion of corrective actions. In May of 1982, the MDC was reported to be initiating a diving contract to clean and repair the fishway. Problems noted to exist at that time included a floating weir which was stuck in position and stoplog guides which had broken off from the wall. The inspection report

recommended that the fishway be dewatered, inspected, cleaned of all debris, and any deficiencies corrected. In May of 1983, the stop log guides were reported to be under repair by a MDC Contract. It was also reported that the fishway pump was inoperable due to a damaged lubrication line to the lower bearing and the contract divers were to repair this line soon.

However, little if any progress appeared to be forthcoming from these efforts. In a letter to the MDC dated 25 January 1985, the New England Division extended its willingness to assist the MDC with adjusting the fishway flows during pump operation once the diffuser pipes were cleaned. Yet in October of 1985, the rehabilitation of the fishway was still reported to be in progress by the MDC. Difficulties mentioned included the plugging of morning glory weirs, the floating weir to be permanently sunk, the fishway pump to be inoperable, and several sections of the outlet stoplog guides that were missing. It is noted that the diffuser pipes were never unplugged until field inspections took place in 1991 under this study. Field inspections confirmed that blockage in the diffuser pipes was due to debris as opposed to other possible reasons such as collapsed piping, faulty valves, etc.

In general, corrective actions to the fishway should have been done under the required operation and maintenance actions as specified in the Operation and Maintenance Manual. The required actions include yearly dewatering, inspection and cleaning of the fishway.

In summary, the problems with the fishway are considered to be due to the lack of maintenance actions and correction under the Section 1135 authority is not appropriate.

NAVIGATION LOCKS

The Charles River Dam included construction of three locks for navigation purposes but did not initially consider lock usage for fish passage purposes. Instead, the concept of locking fish evolved following operation of the facility. Because locking fish has been encouraged by fish and wildlife agencies (Appendix A), continued locking practices were included in this study. The report indicates that the repair or modification of the wet well is needed to reduce saltwater intrusion during locking operations and the Environmental Assessment indicates that automated gates, intended to prevent pedestrians from attempting to cross the dam while the basin locks are opened, should be repaired.

However, maintaining the wetwell is part of the normal operation and maintenance functions for the existing project, since one of the project's objectives is to minimize salt water intrusion into the basin during locking events. This item is addressed in the Operation and Maintenance Manual. Likewise, repair of the automated pedestrian gates is a responsibility of the MDC. In a letter to the MDC dated 15 July 1985, the New England Division indicated that vandalism appeared to be the cause of problems with the pedestrian

gates. When the project was turned over to the MDC, the gate system operated properly. Vandalism occurred because the gates were kept locked preventing pedestrian passage even when the basin gates were closed. The electrically operated interlock system was modified by the MDC so that the pedestrian gates were always in the closed position.

Thus, the existing difficulties with the wetwell and pedestrian gates are considered as part of the normal maintenance requirements and funding to correct these actions under the Section 1135 authority is not appropriate.

SECTION VIII - CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The New England Division, US Army Corps of Engineers, has investigated fish passage problems and opportunities at the Charles River Dam, Boston, Massachusetts. Fish passage facilities consist of a fish ladder and navigation locks. The investigation has determined that effective fish passage opportunities are currently limited at each facility. Operation of the fish ladder occurs at mid to low tides and effective fish passage conditions prevail only at very low tides. Boat locking events are irregular and infrequent during upstream migrations in early spring. This usage limits the opportunity for fish, especially smelt, to gain access to the basin. Downstream fish passage has fewer constraints. The opportunity for downstream passage at the fish ladder is available during mid to low tide ranges when the fishway sluice gate is opened. The opportunity for downstream passage at the navigation locks occurs at times when the locks are frequently and regularly used for boat locking operations. However, the effectiveness of locks to pass downstream juveniles is questionable since river flow occurs mostly on the opposite side of the dam.

Structural and operation modification alternatives were formulated and evaluated to determine enhancements to upstream fish passage capability. Formulation objectives included the ability to alleviate existing project inefficiencies, responsiveness to opportunities, and acceptability to sponsor, agencies and public interests. Evaluation objectives included an assessment of environmental benefits and project costs.

The selected alternative consists of fully restoring the fish ladder to original design conditions and implementing a formal protocol to lock fish. Full restoration of the fish ladder would provide about 1300 hours of effective fish passage time over spring migration seasons. Implementing a formal protocol to lock fish would provide about 55 hours of passage time for smelt and shad and 75 hours for alewife and blueback herring.

The MDC does not endorse the selected alternative. The MDC believes that more definitive environmental information is needed before full restoration should be advocated and that implementation of a formal protocol for locking fish would adversely impact pedestrian usage and safety issues.

However, the investigation revealed that the existing difficulties with the fish ladder and navigation locks are not the result of project construction but are mostly the result of ineffective maintenance following project construction. As a result, funding to restore fish passage is inappropriate under the Section 1135 authority.

Although beyond the scope of this study, water quality related impacts on fish and especially juveniles during passage through the basin is of concern. Further study is needed to investigate issues related to water quality and saltwater intrusion.

RECOMMENDATIONS

As a result of the determination that ineffective maintenance has primarily been the cause of existing difficulties with fish passage, it is recommended that further action to restore fish passage not be pursued under the Section 1135 authority.

21 DEC 92

Date

Brink P. Miller
Colonel, Corps of Engineers
Division Engineer

ENVIRONMENTAL ASSESSMENT

SECTION 1135 PROJECT

FISH PASSAGE IMPROVEMENT

CHARLES RIVER DAM

BOSTON, MASSACHUSETTS

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DECEMBER 1992

New England Division
U.S. Army Corps of Engineers
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TABLE OF CONTENTS

I. INTRODUCTION

This report assesses the environmental effects of a selected plan to restore passage of alewife, blueback herring, shad, and smelt at the Charles River Dam, in Boston, Massachusetts. Presently, a fish ladder at the dam is only partially operational, and provides little effective fish passage. Most alewife and blueback herring passing upstream of the dam probably pass through locks during normal locking for boat traffic. No formal protocol exists for locking fish, however. A protocol is needed because locks are seldom operated during the early spring smelt migrations, and during the early part of the alewife and blueback herring runs. The proposed plan recommends repairing the existing fish ladder and instituting a formal protocol for locking fish.

Authorization for this study is contained in Section 1135 of the Water Resources Development Act of 1986 (PL 99-662).

II. EXISTING CONDITIONS

A. Charles River Dam

1. General

The Charles River Dam is located on the Charles River in Boston, Massachusetts (see Plate 2 of Project Report for location map). The project consists of a 560 foot long earthen and concrete dam, three navigation locks, a pumping station, two flood control sluiceways, and a fish passage facility (see Plate 3 of Project Report). Other features include facilities for harbor patrol craft, a public walkway across the river, offices, and a visitor center. The dam was constructed primarily to prevent flooding by tidal surges in the lower Charles River. The facility was designed and built by U.S. Army Corps of Engineers (Corps) and is operated and maintained by the Massachusetts Metropolitan District Commission (MDC). Construction was completed in 1978.

An impoundment, known as the Charles River Basin, is maintained upstream of the dam. The water level of the "Basin" is normally maintained at 2.5 feet above National Geodetic Vertical Datum (NGVD). Water levels in the harbor vary with the tides. When water level is lower in the harbor than in the Basin, the two flood control sluiceways are used to drain Basin waters. Flow through both sluiceways are regulated by 8 feet wide by 10 feet high sluice gates. The "high" sluiceway is located at the north of and adjacent to the fish passage facility. It has an invert elevation 10.5 feet below the normal Basin water level. The "low" sluiceway is located south of and adjacent to the fish passage facility. It has an invert elevation 21 feet below the normal Basin water level. When water levels are higher in the harbor than in the Basin, pumps may be used to discharge Basin waters into the harbor. Navigation locks are used to drain Basin waters into the harbor only under emergency conditions.

2. Navigation Locks

The navigation locks are situated on the southern (Boston) side of the dam. They include a 300 foot long by 40 foot wide lock for commercial traffic and two 200 foot long by 25 foot wide locks for recreational (small boat) traffic. Minimum water depth in the commercial and recreational locks is 24 and 16 feet, respectively. Culverts situated near the bottom of the locks fill and drain the locks. The locks are filled with Basin water when the Basin level is higher than the harbor level. When the Basin level is lower, the locks are filled with saltwater from the harbor. The facility was designed to minimize saltwater intrusion into the Basin by always discharging drainage water from the locks into the harbor. When water levels are higher in the locks than harbor, this is accomplished by gravity flow. When water levels are higher in the harbor than locks, drainage from the locks is supposed to be pumped back into the harbor via a wetwell. In practice, however, the MDC does not use the wetwell, and drainage water is allowed to flow into the Basin. Under current operating procedures a locking event is typically accomplished in about 5 minutes.

The locks are operated for boat traffic about 12,000 to 13,000 times per year. The frequency of normal operations for boat traffic during the spring and early summer anadromous fish runs is summarized in EA - Appendix A. The locks are also occasionally operated for fish passage when lock operators notice large numbers of fish in the harbor.

3. Fish Passage Facility

Principal components of the fish passage facility include a vertical slot fish ladder with 29 bays, a floating weir at the harbor entrance, a fishway sluice channel, a false weir with exit chute, a pump, and diffuser pipes (see Figure 2 in Appendix B of Project Report). The fish passage facility is designed to allow upstream passage of anadromous fish during the entire tidal cycle. When the water level in the harbor is lower than the water level in the Basin fish passage occurs via the lower 17 bays of the fish ladder and the fishway sluice. During this time adequate fish attraction velocity (i.e. $\geq$ 4 fps) at the ladder's harbor entrance is maintained by gravity flow through the fishway sluice and diffuser pipes, and by the floating weir. When the water level in the harbor is higher than the water level in the Basin, flow through the ladder is maintained by a pump. Under the pumped flow mode, fish pass through all 29 bays and into the Basin via the false weir exit chute. Pumped flow is required to maintain adequate attraction velocity during about 45 percent of the tidal cycle.

The fish passage facility has never been fully operational. At present, the pump is not installed and operation is limited to the gravity mode. Furthermore, the facility is largely ineffective during the gravity mode because the floating weir is damaged and diffuser pipes are clogged. Attraction flow needed to provide "effective" fish passage currently occurs less than one percent of the time at the facility.

B. Fish Passage Under Current Conditions

1. Adults

Under existing conditions substantial numbers of alewife and blueback herring are able to pass the Charles River Dam, as evidenced by their presence at the Watertown Dam fish ladder, 8.6 miles upstream. Lesser numbers of smelt and a few shad also pass through the dam. The percentage of migrating fish which successfully pass upstream of the dam is unknown. Also unknown is how long fish are delayed prior to passage.

Most alewife, blueback herring, and shad currently passing through the dam probably pass via the locks during locking for boat traffic. Locking from mid March through June provides about 1 to 2 hours of passage time for smelt, 25 to 40 hours for alewife and blueback herring, and 45 to 50 hours for shad (see Appendix F of Project Report). Effective fish passage at the ladder during the same period is limited to about 30 hours. Some fish passage probably occurs through the flood control sluiceways. Suitable conditions for passage occur about 6 percent of the time in the high sluiceway and 60 percent of the time in the low sluiceway. Actual fish passage via the sluiceway may be quite limited, however, because fish are probably reluctant to venture into the dark sluiceway channels, especially during daylight hours.

Most smelt passing the dam probably pass either through the sluiceways or locks. Smelt negotiate fish ladders poorly, and few would utilize the Charles River Dam facility, even if it were fully operational. Locks currently provide only about 1 to 2 hours of potential passage time for smelt because very little locking occurs during the smelt migration season (mid March through April). In addition, smelt typically migrate at night, when little locking activity takes place.

Under current conditions, fish sometimes become trapped in the fishway as tides change. Fish kills occasionally occur in the upper bays of the ladder, apparently when large numbers of fish become trapped, and oxygen levels in bay waters become depleted.

2. Juveniles

Downstream migration of juvenile anadromous fish occurs in the Charles River from April through November. Juveniles tend to be surface orientated, and most passing the dam probably pass via the high sluiceway or the fishway during gravity flow operation. Some probably also pass through locks. No information is available about the percentage of juveniles which successfully pass downstream of the dam. Although the condition of juveniles passing through the drainage sluiceway is not known, some are probably injured by shear stress or abrasion during passage.

III. MODIFICATION SELECTION

A. Selected Plan

1. Fish Passage Facility

Full restoration of the fish passage facility to improve upstream passage of alewife, blueback herring and shad is selected from alternatives that were evaluated. The selected modification would require repairing and reinstalling the fishway pump and floating weir, and improving maintenance practices. The facility would be operated during daylight hours from 1 April until June 30. These actions would increase the effective passage time available at the facility from 30 hours to 1,300 hours per year. The facility would be operated in the gravity flow mode through November to facilitate downstream migration of juveniles.

2. Navigation Locks

A formal locking protocol to restore upstream passage of adult smelt, alewife, blueback herring, and shad would be instituted. The protocol is designed to supplement incidental fish passage that occurs during normal locking for boat traffic.

The proposed procedure for locking fish is as follows:

1) open harbor gate of one of the small navigation locks for about 30 minutes to allow fish to enter the lock

2) close harbor gate and adjust the water level in lock to that of the basin

3) open basin gate for 10 minutes to allow fish to enter the basin

Boat traffic and pedestrians would sometimes result in gates being closed more quickly than indicated above. This would probably happen occasionally in March and April and frequently from mid May through June.

Locking for fish passage would occur according to the following general schedule:

<u>March 15 to March 31</u>

o Upstream locking once each hour during the night (for smelt)

o Downstream locking once each day during the day (for smelt)

<u>April 1 to April 30</u>

o Upstream locking once each hour during the night (for smelt)

o Upstream locking once each hour during the day (for alewife, blueback herring)

May 1 to May 30

- o Upstream locking once each hour during the day (for alewife, blueback herring, and shad).

June 1 to June 30

- o Upstream locking once each hour during the day (for shad).

To minimize saltwater intrusion into the Basin, upstream locking for fish passage would generally occur only when water levels in the harbor were lower than in the Basin (about 60 percent of the time). Incidental fish passage during normal navigation locking would continue to occur during the remainder of the tidal cycle.

Additional locking for fish passage would be permitted at any time during the tidal cycle when peak runs were known to be underway (based either on observations by MDC personnel at the Charles River Dam or information provided by Massachusetts Division of Marine Fisheries).

The proposed protocol would provide about 55 hours of passage time for smelt and shad and 75 hours for alewife and blueback herring (passage time is based on the amount of time lock gates are open).

Monitoring using radio tagged smelt and alewife would be used to determine if the locking protocol is effective (see EA - Appendix B).

B. Alternatives

A number of alternative plans for providing fish passage at the Charles River Dam were considered (see Formulation of Alternatives Section of Project Report). These include the following:

- o No Federal action.
- o Closure of fish passage facility and development of protocol for locking fish
- o Complete restoration of fish passage facility with development of protocol for locking fish
- o Complete restoration of fish passage without developing a protocol for locking fish

- o Partial restoration of fish passage facility with development of protocol for locking fish

- o Partial restoration of fish passage without developing a protocol for locking fish

- o Construction of a new fish passage facility

Aside from the selected plan, the most feasible alternative was partial restoration of the fish passage facility along with implementation of a locking protocol. This alternative was not selected primarily because an incremental analysis (see Evaluation of Alternatives Section of Project Report) showed that full restoration of the facility nearly doubled effective passage time, at a lower incremental cost.

IV. ENVIRONMENTAL RESOURCES

A. General Setting

The Charles River watershed encompasses 307 square miles in eastern Massachusetts (see Plate 1 of Project Report). The river arises in Echo Lake in the town of Hopkinton and flows in a general northeasterly direction for 80 miles before emptying into Boston Harbor at the Charles River Dam. The river is generally sluggish, with a total fall in elevation of less than 400 feet, including a 200 feet drop within the first 20 miles. Major tributaries to the Charles include Bogastow Brook, Stop River, Chicken Brook, and Stony River. There are about 20 existing dams on the Charles, and a substantial portion of the lower river is impounded.

The lower third of the Charles River passes through heavily urbanized sections of the Boston metropolitan area. The middle third of the watershed is moderately developed, and the upper third is largely rural and forested. The Corps owns about 8100 acres of low lying areas in the basin (4 percent of total basin area). These areas serve as natural valley storage areas for flood control protection.

The vicinity of the Charles River Dam is heavily urbanized. The dam is within walking distance of "North Station", a major public transportation station, and the Boston Garden. Much of downtown Boston to the south, and Charlestown to the north, is within one mile of the dam. Construction associated with the Central Artery transportation project is underway on the north side of the river. As part of this project, a new bridge will be built across the Charles several hundred feet upstream of the dam.

The "Basin" portion of the Charles River passes through a heavily urbanized area, including portions of Boston, Cambridge, Newton and Watertown. The Massachusetts Institute of Technology, Harvard, Boston University, the Museum of Science, and a public

park (the "Esplanade") are present along the Basin, within a few miles of the dam.

B. Water Quality

Water quality in the Charles River Basin is rated as Class B by the Massachusetts Division of Water Pollution Control (MDWPC). Class B waters are designated as acceptable for fish and wildlife habitat, primary and secondary contact recreation, industrial and agricultural use, and for water supply, following appropriate treatment (criteria for Class B waters are given in Appendix C of the Project Report).

Waters downstream of the dam are considered to be coastal marine and rated Class SB by the MDWPC. With a few slight differences, requirements for Class SB waters are similar to those for Class B.

In general, Charles River water quality does not meet Class B standards (see Appendix C of Project Report). The primary problem is a stratified layer of saltwater present upstream of the dam. This saltwater "wedge" is formed as a result of saltwater intrusion into the Basin, mostly during normal locking operations. The wedge forms because saltwater is more dense than freshwater, and tends to sink to the bottom of the Basin. Difference in density limit mixing of salt and freshwater strata, especially in deeper areas of the Basin near the dam. Under stratified conditions very low levels of dissolved (DO) oxygen and high levels of hydrogen sulfide develop in the wedge. Levels of DO are regularly below Class B standards. Levels of hydrogen sulfide in bottom waters can be well above criteria established to protect aquatic life. Mixing of saltwater and freshwater in shallow areas of the Basin can also release high levels of hydrogen sulfide into oxygenated surface waters. These releases have caused fish kills in the past and also pose on odor problem. Efforts to improve water quality conditions by using diffusers to destratify the saline waters have met with only limited success. To date, no measures have been taken to limit saltwater intrusion into the Basin or drain saline Basin waters into the harbor.

C. Biological Resources

1. Fish

The Charles River and its tributaries once supported excellent runs of American Shad, alewife, blueback herring, smelt, sea bass, and Atlantic salmon. These runs were virtually eliminated by the twentieth century by numerous dams which blocked access to spawning grounds and by poor water quality in the lower Charles River.

Efforts to restore anadromous fish runs in the Charles River have been underway for many years. In recent years, passage facilities have been built or improved at several dams upstream of the Charles River Dam. Alewife, blueback herring, and shad can currently reach upstream to the Circular Dam in Wellesley. Plans are in preparation for a fishway at this dam, and at the next upstream obstruction (the Silkmill Dam in Wellesley). Eventually,

access to nearly 1,250,000 square yards (260 acres) of spawning habitat for alewife, blueback herring and shad could be available in the basin. Smelt access to the basin is much more limited. At present, few smelt migrate upstream of the Watertown dam because they cannot easily negotiate the denil-type fish ladder present at the dam. Smelt currently spawn in the shallow water area immediately downstream of Watertown Dam. There are currently no plans to improve smelt passage at the Watertown Dam.

Efforts have been underway to restore shad in the Charles River basin since 1969. About 9.5 million eggs were stocked from 1971 through 1978, and since 1979 about 1,000 to 2,000 adults per year have been stocked. Although returns of natal fish have been documented, shad restoration efforts have met with only limited success. To date, the maximum yearly number of shad known to pass the Watertown Dam fish ladder is 16.

No population estimates for anadromous species are available for the Charles River. In general, however, runs of alewife and blueback herring have been good since 1984. Smelt runs have declined in recent years, but this may reflect a general decline in southern Massachusetts populations, rather than conditions unique to the Charles. Shad numbers have remained very low in recent years. Atlantic salmon do not currently occur in the river, but may be the focus of restoration efforts in the future.

The timing of spawning runs vary between species, and from year to year depending on water temperature. Smelt runs may occur from March 15 until the end of April. Alewife and blueback herring runs occur from April through the end of May, with blueback runs tending to peak somewhat later than alewife. Shad runs typically occur from mid May through mid June.

Alewife and blueback herring are likely to migrate primarily during the day. Shad probably migrate both during the day and night in the Charles River. Based on smelt behavior in other rivers, smelt runs in the Charles probably occur mostly at night.

Although no specific information is available for the Charles, in general alewife and blueback herring tend to occur near the water surface (top 3 feet) during spawning runs. Shad typically also occur near the water surface. No information is available concerning depth preferences of smelt.

Downstream migrations of juveniles in the Charles occur from April through October. Juvenile smelt migrate downstream from April through May. Juvenile alewife and blueback herring migrate from July through mid November. Juvenile shad migrate during from October through early November. Juveniles are surface orientated, and are mostly concentrated within the top 2-3 feet of the water column. Downstream migration in the river probably occurs during both night and day. Downstream passage through the sluiceways and fishway at the Charles River Dam can occur only during the low tide cycle.

Predominant freshwater species present in the the Charles River Basin include white catfish, brown bullhead, yellow perch, black crappie, and common sunfish. Populations of

these species are generally low. Saltwater species such as striped bass and white perch are also present, but do not spawn in the Basin.

2. Wildlife

The project area is heavily developed and has minimal wildlife habitat value. Species likely to occur in the area include house sparrow, rock dove, starling, Norway rat and others characteristic of urban habitat in the northeastern U.S. Gulls and cormorants are also common in the area.

3. Threatened and Endangered Species

No threatened or endangered species are known to occur in the project area (see letter from Chris Mantzaris, National Marine Fisheries Service).

D. Cultural Resources

The Charles River Dam lies within the Charles River Basin Historic District, which is listed on the National Register of Historic Places. This Historic District lies on the north and south banks of the Charles River and extends from east to west, from the Charles River Dam to the Elliot Bridge. It includes: the Charles River Basin, parkways and landscaped areas on both banks from the Dam to the Elliot Bridge; Memorial Drive and the Cambridge Parkway, Cambridge; Embankment Road, James J. Storrow Memorial Drive and Soldiers Field Road, Boston; the Charles River Dam; seven bridges; two canals; the fresh water basin; the parkland surrounding the basin, and numerous miscellaneous structures (police headquarters, boat houses and garages, the Museum of Science, and a street railway viaduct to name a few).

E. Socio-Economic Resources

The Charles River Dam, including the fish passage facility, is readily accessible to the public, and draws numerous visitors each year. A small visitor center at the dam includes a display about the fish passage facility. There is considerable pedestrian traffic at the dam, particularly during the morning and evening commutes, during lunch hour, and before and after events at the nearby Boston Garden.

Recreational boat traffic is very heavy in the lower Charles River, and thousands of boats pass through the Charles River Dam locks each year. Recreational traffic is heaviest between mid May and late September.

The Charles River Basin offers recreational opportunities to millions of Boston area residents. The "Esplanade" a park, situated along the basin a few miles upstream of the Charles River Dam is heavily utilized. Concerts and other events are frequently held at the "Hatch Shell", an outdoor amphitheater situated on the Esplanade.

Some fishing for anadromous fish occurs near the Charles River Dam, particularly on the harbor side of the dam. Limited fishing for warmwater species (yellow perch, sunfish, brown bullhead) occurs in the Basin.

V. ENVIRONMENTAL CONSEQUENCES OF SELECTED ACTION

A. Water Quality

Increased locking for fish passage would introduce some additional saltwater into the Charles River Basin. This impact is not considered significant since the amount of saltwater introduced by locking for fish passage would be small relative to the volume of the existing salt wedge and the amount of saltwater introduced by lock operations for boat traffic (the proposed protocol would result in only a 3-4 percent increase in number of yearly lock operations). Additional saltwater intrusion has been minimized by limiting locking for fish passage primarily to low tide periods when most drainage water from the locks enters the harbor.

In the long-term, repair or modification of the wet well is needed to reduce intrusion of saltwater into the basin during all locking operations.

B. Biological Resources

1. Fish

The selected modifications will support ongoing efforts to restore anadromous fish populations in the Charles River basin. The formal locking protocol would greatly increase passage opportunity for smelt, and to a lesser extent alewife, blueback herring, and shad. Repair of the fishway would greatly increase passage opportunity for alewife, blueback herring, and shad.

The selected modifications will undoubtedly benefit Charles River populations of smelt, alewife, blueback herring, and shad to some degree. It is likely that the improvements would increase the percentage of migrating fish which successfully pass upstream of the dam. Because no information about fish passage at the dam under existing conditions is available, however, this benefit cannot be quantified. The modifications should also reduce delays migrating fish experience at the dam. Shorter delays would reduce stress on fish during spawning runs, and reduce risk of predation while fish are delayed at the dam.

Passage of adult anadromous fish at the Charles River would be monitored using radio tagged smelt and alewife following implementation of the selected plan. The monitoring would determine how fish pass through the dam (locks, fishway, or drainage sluiceway), delay time at the dam, and the effectiveness of the locking protocol. Minor changes in operating procedures may be made based on results of the monitoring.

The selected modifications would not substantially enhance downstream passage of juveniles at the Charles River Dam. Under current operating conditions, the fishway already probably provides for passage of substantial numbers of juveniles during the gravity flow mode (ca. 60 percent of the tidal cycle). Further studies, however, are needed to confirm this and determine if additional measures to pass juveniles downstream are required. No other practicable alternatives to enhance downstream passage of juveniles are available.

Additional locking could be conducted in the fall, but locking is probably not a very effective way of passing juveniles. Unless the navigation locks were to experience continuous sluicing, the effectiveness of locks to pass downstream juveniles is questionable since river flow occurs mostly on the opposite side of the dam. Opening of locks to sluice juveniles downstream as suggested by the US FWS and MA DMR, was ruled out due to safety and technical concerns. Safety concerns include protecting the basin from flooding and safe passage of navigation traffic. Technical concerns include wear and tear of lockage equipment, particularly during potential high velocities that would occur at low tide conditions.

In addition to improved passage opportunity for anadromous fish, repairing the wet well is needed to reduce saltwater intrusion into the Basin. Under existing conditions some mortality of both adult and juvenile migrants probably occurs in the Basin due to poor water quality caused by the dam. Poor water quality may be especially critical to juveniles, which may be delayed in the Basin for a substantial period of time prior to downstream passage.

2. Wildlife

The proposed modifications will have no impact on existing wildlife resources.

3. Threatened and Endangered Species

The proposed plan will have no impact and any Federal or state listed or proposed rare, threatened, or endangered species.

C. Cultural Resources

The most favorable project alternative consists of completely restoring the fish passage facility to design specifications and to develop a formal protocol for passing fish through locks. Since this alternative will only involve modifications to existing structures, the project should have no effect on significant historic properties as defined by the National Historic Preservation Act of 1966, as amended. The Massachusetts State Historic Preservation Officer, in a letter dated February 13, 1992, has concurred with these determinations.

D. <u>Socio-Economic Resources</u>

Although the proposed modifications will probably enhance populations of anadromous fish in the Charles River to some degree, it is impossible to quantify this benefit in economic terms.

During operation of locks for fish passage, the open Basin-side gates may slightly delay pedestrians crossing the dam. No delays would be incurred when the harbor-side gates are open. Open Basin-side gates also pose a slight safety risk, because automated gates intended to prevent pedestrians from attempting to cross the dam while the locks are open are broken. The MDC has been advised that the safety gates should be repaired.

V. COORDINATION

A. <u>Letters Sent</u>

Gordon Beckett (U.S. Fish and Wildlife Service Region V)

<u>October 16, 1991</u>: Requested comments on project pursuant to Fish and Wildlife Coordination Act.

<u>January 15, 1992</u>: Provided additional information about existing conditions at the Charles River Dam and requested revised comments pursuant to the Fish and Wildlife Coordination Act.

Thomas Bigford (National Marine Fisheries Service)

<u>October 16, 1991</u>: Requested comments pursuant to Fish and Wildlife Coordination Act and Endangered Species Act.

Philip G. Coates (Massachusetts Division of Marine Resources)

<u>October 16, 1991</u>: Requested comments pursuant to Fish and Wildlife Coordination Act.

Judith McDonough (Massachusetts Historic Commission)

<u>December 18, 1991 and January 29, 1992</u>: Requested comments pursuant Section 106 of the National Historic Preservation Act.

B. <u>Letters Received</u> (see also the Appendix)

Gordon Beckett (U.S. Fish and Wildlife Service Region V)

November 22, 1991: Suggested that formal locking protocol be established and that repair of the fish passage facility was necessary; expressed concerns regarding downstream passage of juveniles.

February 10, 1992: Supported partial restoration of fish passage facility along with formal locking protocol (note: this letter inaccurately referred to partial restoration of the fish passage facility as Corps preferred alternative).

March 2, 1992: Clarified February 10 letter to indicate that either partial or full restoration of the fish passage facility is an acceptable alternative.

Chris Mantzaris (National Marine Fisheries Service)

October 31, 1991: Indicated that no threatened or endangered species are known to exist in the project area.

Judith McDonough (Massachusetts Historic Commission)

October 31, 1991: Requested additional information about project plans.

February 13, 1992: Determined that the project would have no significant impact on any property listed on the National Register of Historic Properties.

C. Personal Communications

Phil Brady (Massachusetts Division of Marine Fisheries)

January 7, 1992: Provided information about Charles River fisheries resources, including seasonal timing of anadromous runs.

February 22, 1991: Provided additional informational on Charles River fisheries resources, including seasonal timing of juvenile migrations.

Douglas Cook (South Carolina Dept. Fish and Game)

January 21, 1992: Provided information on procedures for locking fish at a dam on the Sante-Cooper River, South Carolina.

Joseph DiCarlo (Massachusetts Division of Marine Fisheries)

December 9, 1991: Provided information about Charles River fisheries resources.

Dan Kusmeskus (U.S. Fish and Wildlife Service)

January 3, 1992: Provided suggestions regarding monitoring program using radio tagged fish.

Meetings were held between the Corps and resource agencies on June 11 and December 18, 1991 to discuss existing conditions and potential modification at the Charles River Dam. Participants at the June 11 meeting included Ben Rizzo (USFWS), Joseph DiCarlo (MA DMR), and Paul DiPietro (MDC). Participants at the December 18 meeting included Ben Rizzo, Paul DiPietro, Joseph DiCarlo, Phil Brady (MA DMR), and Nancy Haley (NMFS).

VIII. COMPLIANCE WITH FEDERAL ENVIRONMENTAL STATUTES, EXECUTIVE MEMORANDUM, AND EXECUTIVE ORDERS

Federal Statutes

1. Preservation of Historic and Archaeological Data Act of 1974, as amended, 16 U.S.C. 469 et seq.

Compliance: Consultation with the State Historic Preservation Office and the Advisory Council on Historic Preservation concerning mitigation of historic and/or archaeological resources signifies compliance.

2. Clean Air Act, as amended, 42 U.S.C. 7401 et seq.

Compliance: Public notice of the availability of this report to the Environmental Protection Agency signifies compliance pursuant to Sections 176c and 309 of the Clean Air Act

3. Clean Water Act of 1977 (Federal Water Pollution Control Act Amendments of 1972) 33 U.S.C. 1251 et seq.

Compliance: Project will have no significant adverse affect on water quality.

4. Coastal Zone Management Act of 1972, as amended, 16 U.S.C. 1431 et seq.

Compliance: Proposed project is consistent with the approved State CZM program.

5. Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 et seq.

Compliance: Coordination with the National Marine Fisheries Service has yielded no

formal consultation requirements pursuant to Section 7
of the Endangered Species Act.

6. Estuarine Areas Act, 16 U.S.C. 1221 et seq.

Compliance: Not applicable.

7. Federal Water Project Recreation Act, as amended, 16 U.S.C. 4601-12 et seq.

Compliance: Public notice of the Availability of this report to the National Park Service (NPS) and the Office of Statewide Planning relative to the Federal and State comprehensive outdoor recreation plans signifies compliance with this Act.

8. Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661 et seq.

Compliance: Coordination with the U.S. FWS, NMFS, and state resource agencies signifies compliance with the Fish and Wildlife Coordination Act.

9. Land and Water Conservation Fund Act of 1965, as amended, 16 U.S.C. 4601-4 et seq.

Compliance: Public notice of the availability of this report to the National Park Service (NPS) and the Office of Statewide Planning relative to the Federal and State comprehensive outdoor recreation plans signifies compliance with this Act.

10. Marine Protection, Research, and Sanctuaries Act of 1972, as amended, 33 U.S.C. 1401 et seq.

Compliance: Not Applicable.

11. National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq.

Compliance: Coordination with the State Historic Preservation Office and Advisory Council on Historic Preservation determined that no historic or archaeological resources would be affected by the proposed project

12. National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321 et seq.

Compliance: Preparation of this report signifies partial compliance with NEPA. Full compliance shall be noted at the time the Finding of No Significant Impact is issued.

13. Rivers and Harbors Act of 1899, as amended, 33 U.S.C. 401 et seq.

Compliance: No requirements for Corps' projects or programs authorized by Congress.

14. Watershed Protection and Flood Prevention Act, as amended, 16 U.S.C. 1001 et seq.

Compliance: Not applicable.

15. Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271 et seq.

Compliance: Not Applicable.

Executive Orders

1. Executive Order 11988, Floodplain Management, 24 May 1977 amended by Executive Order 12148, 20 July 1979.

Compliance: Not Applicable.

2. Executive Order 11990, Protection of Wetlands, 24 May 1977.

Compliance: Circulation of this report for public review fulfills the requirements of Executive Order 11990, Section 2(b).

3. Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, 4 January 1979.

Compliance: Not Applicable.

Executive Memorandum

1. Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing NEPA, 11 August 1980.

Compliance: Not Applicable.

EA - APPENDIX A

Summary of 1989 and 1990 Navigation Locking at the Charles River Dam

Charles River Dam Locking Summary*

Interval	1989 Monday - Friday		1989 Saturday & Sunday		1990 Monday - Friday		1990 Saturday & Sunday	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
3/01 - 3/15	0.3	0 - 1	0.0	0	0.3	0 - 5	2.0	1 - 4
3/16 - 3/31	1.6	0 - 7	1.0	0 - 4	1.6	0 - 7	1.6	0 - 3
4/01 - 4/15	2.0	0 - 5	3.8	0 - 12	2.4	1 - 7	6.4	2 - 19
4/16 - 4/30	11.1	1 - 30	11.4	0 - 27	9.9	1 - 35	18.3	3 - 35
5/01 - 5/15	11.1	2 - 25	37.0	28 - 43	12.5	2 - 26	20.5	3 - 47
5/16 - 5/31	27.1	5 - 59	54.0	34 - 73	14.9	0 - 65	39.5	21 - 51
6/01 - 6/15	17.2	2 - 40	71.5	50 - 70	29.3	9 - 54	48.3	37 - 59
6/16 - 6/30	37.4	12 - 48	63.4	51 - 83	30.3	17 - 61	60.6	41 - 79

*All values refer to number of upstream locking events per day.

Charles River Dam Locking Summary

Month	Average Number of Events/Day (upstream + downstream)	
	1989	1990
July	93*	95
August	84	74
September	59	61
October	36	26
November	6	8

*: July 9 - July 30

EA - APPENDIX B

Monitoring Plan

MONITORING PLAN

After repair of the fish passage facility and implementation of the locking protocol fish passage at the Charles River Dam will be monitored using radio tagged smelt and alewife. Monitoring will provide the following information:

- o relative number of fish passing through the locks, fish passage facility, and sluiceways.
- o length of delay imposed by the dam on upstream migrants
- o adequacy of locking protocol (i.e. does the protocol allow sufficient time for fish trapped in the lock to exit into the basin ?)

Monitoring will occur during the normal spring alewife and smelt runs. Fish used in the study will be collected from Boston Harbor, tagged, and released near the Charles River Dam. Fish movement will be monitored by stationary receivers connected to automated data recorders. Receivers will be placed in the harbor, the basin upstream of the dam, navigation locks, and the fishway. Approximately 30 individuals of each species will be tagged and released. Releases will occur at high, low, and mid tide conditions. Estimated cost of this study is 30 k.

APPENDIX A

LETTERS OF CORRESPONDENCE AND COORDINATION

The Commonwealth of Massachusetts
Metropolitan District Commission
M. Ilyas Bhatti, Commissioner

20 Somerset Street
Boston, MA 02108
617-727-5114

The Metropolitan Network of Services

Parks

Beaches

Community Boating

Historic Sites

Recreational Facilities

Public Concerts

Trailside Museum

Boston Harbor Islands

Metropolitan Police

Flood Control

Watershed Management

Pure Water Supply

Quabbin, Wachusett and Sudbury Reservoirs

Franklin Park and Stone Memorial Zoos

Parkway, Boulevard and Bridge System

Charles, Mystic and Neponset Rivers

Beaver Brook, Blue Hills, Elm Bank, Breakheart, Middlesex Fells, and Stony Brook Reservations

March 21, 1991

Joseph L. Ignazio, Director
Planning Directorate
Army Corp of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

RE: Charles River Dam, Anadromous Fish Passage Facility

Dear Mr. Ignazio:

It is my understanding that the Army Corps of Engineers has been granted authority to improve the quality of the environment for fish and wildlife as you indicated in your letter of March 1, 1991. As a result of this new authority, the opportunity exists for the MDC to enhance the operational efficiency of the fish passage facility at the Charles River Dam.

The Metropolitan District Commission (MDC) is participating with the United States Fish and Wildlife Service and Massachusetts Marine Fisheries in the restoration of American Shad to Charles River. The MDC construction of fish ladders will allow shad migration to ancestral spawning areas. It is important that the deficiencies be corrected at the Charles River Dam fish passage facility since this is the estuarine gateway to their spawning grounds. The current solution to this problem is for MDC personnel to operate the locks at the Charles River Dam so as to allow the migrating fish to pass through the locks to the spawning grounds, a cumbersome solution at best.

It is the intention of the MDC to work with the Army Corp to effect corrective changes at the fish ladders which will result in their proper operation. Based on your new authority and funding the MDC will seek funds for local cost sharing obligations upon completion of all preliminary steps.

If the MDC can be of further assistance, please contact Noel Baratta, Deputy Commissioner and Chief Engineer, (617) 727-5114, for further action on this matter.

Sincerely,

M. Ilyas Bhatti
Commissioner

cc: Noel D. Baratta, Deputy Commissioner/Chief Engineer, MDC
Francis Faucher, Director, Engineering and Construction, MDC
Carney Terzian, Section Head, Flood Control, MDC
Paul DiPietro, Project Engineer, Flood Control, MDC

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northeast Region
Habitat and Protected Resources Division
One Blackburn Drive
Gloucester, MA 01930-2298

October 31, 1991

Joseph L. Ignazio
Army Corps of Engineers
Impact Analysis Division
424 Trapelo Road
Waltham, MA 02254-9149

Dear Mr. Ignazio:

This letter responds to your request for comments on the proposed fishway at the Charles River Dam in Boston, Massachusetts pursuant to the Endangered Species Act.

There are no endangered species under the National Marine Fisheries Service's jurisdiction that would be effected by the proposed fishway. Please keep us informed of any further information regarding this study as we may have concerns regarding this proposal from a fishery resource standpoint. If you have any more questions, please contact Nancy Haley at FTS 837-9388 or (508) 281-9388.

Sincerely,

Chris Mantzaris
Habitat Program Coordinator

cc:
US FWS, Concord, NH - Ben Rizzo
MA DMF, Sandwich, MA - Joseph DiCarlo
NMFS, Narragansett, RI - Jonathan Kurland
NMFS, Doug Beach - Section 7 Files

MASSACHUSETTS ★ HISTORICAL ★ COMMISSION ★
A CommonWealth to Keep ★

October 31, 1991

Joseph L. Ignazio
Director of Planning
Impact Analysis Division
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02254-9149

RE: Charles River Dam Fish Passage Facility, Boston, MA

Dear Mr. Ignazio:

Thank you for submitting information regarding the preliminary planning on the project referenced above, received by the Massachusetts Historical Commission on Ocotober 22, 1991. Staff of the MHC have reviewed the information you submitted.

The proposed project appears to be within or contiguous to the Charles River Basin Historic District, listed on the National Register of Historic Places. Currently, I am unable to concur that the proposed project will have no effect (36 CFR 800.5(b)) on the district without the opportunity to review plans of the proposed preferred alternatives. Please submit project plans when they are available for review in compliance with Section 106 of the National Historic Preservation Act of 1966 as amended (36 CFR 800). It would facilitate review of the proposed project to submit plans concurrently to the Boston Landmarks Commission, City Hall, 8th Floor, Boston, MA 02201.

Thank you for your cooperation. Should you have any questions or require further assistance, please feel free to contact Ed Bell at this office.

Sincerely,
Judith B. McDonough
Judith B. McDonough
Executive Director
State Historic Preservation Officer
Massachusetts Historical Commission

xc: Boston Landmarks Commission
Advisory Council on Historic Preservation

Massachusetts Historical Commission, Judith B. McDonough, *Executive Director, State Historic Preservation Officer*
80 Boylston Street, Boston, Massachusetts 02116 (617) 727-8470
Office of the Secretary of State, Michael J. Connolly, *Secretary*

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

February 10, 1992

Mr. Joseph L. Ignazio, Chief
Planning Directorate
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

Attention: Impact Analysis Division

Dear Mr. Ignazio:

We have reviewed your letter dated January 17, 1992 regarding modifications to the Charles River Dam to improve fish passage. Based on the information provided, and consultation with Mr. Ben Rizzo of our Regional Engineering Office, we concur with your preferred alternative of the partial restoration of the fish passage facility along with a formal lock operations protocol. We appreciate this opportunity to comment. If you have any questions regarding these comments, please contact John Warner of this office at (603) 225-1411.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

November 22, 1991

Mr. Joseph L. Ignazio, Chief
Planning Directorate
New England Div., Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

Attention: Impact Analysis Division

Dear Mr. Ignazaio:

We have reviewed your letter dated October 16, 1991 regarding modifications to the Charles River Dam to improve fish passage, and have consulted with Mr. Ben Rizzo of our Regional Engineering Office and Mr. Joseph DiCarlo of the Massachusetts Division of Marine Fisheries (MDMF).

The existing lock system appears to be functioning adequately for the upstream passage of American shad, blueback herring, and alewife. We believe that a protocol for operating the locks for fish passage needs to be formally established. Once established, further expenditures for repair or replacement of the existing fish ladder system does not appear necessary. Therefore, we suggest that your alternative 2 be selected.

A far greater concern to us is providing for downstream passage of outmigrating juvenile shad, herring, and alewife. During September, October, and November (precise dates should be discussed with MDMF), continuous sluicing of flows is needed to provide efficient outmigration. We urge you to investigate options for downstream passage and develop a downstream passage protocol.

Please continue consultation with us and the MDMF regarding the upstream passage protocol and the downstream passage issue.

Thank you for this opportunity to comment and if you have any further questions please contact Mr. John Warner of this office at 603-225-1411.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

March 2, 1992

Mr. Joseph L. Ignazio, Chief
Planning Directorate
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

Attention: Impact Analysis Division

Dear Mr. Ignazio:

This letter is intended to clarify our letter dated February 10, 1992, regarding your proposed modifications to the Charles River Dam to improve fish passage. In that letter, we identified that we concurred with your preferred alternative of partial restoration of the fish passage facility, along with a formal lock operations protocol. However, we had intended to endorse either partial or full restoration of the facility, whatever alternative was found to provide the best fish passage conditions based upon your further analysis.

I trust this clarifies our support of your project. If you have any questions regarding these comments, please contact John Warner of this office at (603) 225-1411.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

February 13, 1992

Joseph L. Ignazio
Director of Planning
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

RE: Charles River Dam Fish Passage Facility, Boston, MA

Dear Mr. Ignazio:

Thank you for submitting additional information, received February 4, 1992, regarding the preliminary planning on the restoration of the Charles River Dam Fish Passage Facility. The project location is within the Charles River Basin Historic District, which is listed in the National and State Registers of Historic Places.

After reviewing the materials submitted, MHC staff has determined that the proposed full or partial restoration of the facility will have no effect on the significant architectural and historical characteristics of the National Register district.

These comments are provided to assist in compliance with Section 106 of the National Historic Preservation Act (36 CFR 800).

If you have any questions, please contact Diana Prideaux-Brune at this office.

Sincerely,

Judith B. McDonough

Judith B. McDonough
Executive Director
State Historic Preservation Officer

cc: Boston Landmarks Commission
Cambridge Historical Commission

The Commonwealth of Massachusetts

Metropolitan District Commission

M. Ilyas Bhatti, Commissioner

Noel D. Baratta P.E.
Deputy Commissioner
Chief Engineer of
Technical Services
20 Somerset Street
Boston, MA 02108
617-727-2556
Fax 617-727-0891

June 8, 1992

Mr. Joseph Ignazio
Chief Planning Section N.E.D.
Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02154-9149

RE: Fish Passage Modification Charles River Dam, Boston, MA

Dear Mr. Ignazio:

On behalf of the Metropolitan District Commission (MDC), I appreciated the detailed analysis that the Corps has performed on the Fish Passage Facility at the Charles River Dam. The meeting with your staff provided us an opportunity to explore the details of the Draft report.

The MDC can not endorse the full restoration of the fish passage facility at this time. The operational reliability has not been proven neither has the need for a full restoration.

At this time, I believe it is in the best interest of the Commonwealth to proceed with a partial restoration, a modified locking operation for smelt and the study to monitor the migrant fish population entering the basin. This will provide a basis to determine whether or not a full restoration is necessary.

Please contact me if you have questions concerning this project.

Sincerely,

Noel D. Baratta, P.E.
Chief Engineer
Deputy Commissioner

PJD/cmf

wp:CorpCRD

Attachment

cc: J. O'Brien
F. Faucher
N. Winter
C. Terzian
P. DiPietro

COMMENTS

Fish Passage Modification - Corps Draft Report
Charles River Dam

General

1. It should be understood that Shad is the target species for restoration, in the Charles River Watershed. There are already abundant populations of Alewife and Herring in the basin. This information has been discussed with fisheries personnel on numerous occasions. Therefore, we should concentrate effects on Shad. Shad have been documented at the Watertown Dam.

2. Page 11 - "Fish ladder never operated as designed" initial tests debris blocked pipes causing pump to burn out. Why weren't corrective steps taken to correct this major deficiency by the contractor during the warranty period. Also, see Page B-1, Section 2 Paragraph 2, and Page B-3 , Section 4 Paragraph 1.

3. Page EA-7 bottom line - change " to inject oxygen into" ... to destratify. Project was never intended to directly oxygenate.

4. Page EA-10 Paragraph E delete last sentence. It is vague and unsubstantiated.

5. Page D-4 Paragraph I, original design called for strap anchoring stop log guides on harbor end but small diameter carbon bolts were used. Why weren't appropriate items installed so that corrosion maintenance issues were reduced?

6. Fish monitoring program for radio tagging fish is not necessary at this time and should be instituted by Fisheries Management people. When all fish ladders are in place Shad should be monitored as an overall performance appraisal.

7. How will the fish that get caught in upper 12 bays during low tide cycle be kept alive? I still suggest a permanent closing of the pumped side. This will reduce changes of fish mortality and operating & maintenance costs.

8. Project Costs of Fish Ladder Options - Table 1 Page 17 should include feasibility report costs.

9. Replacements, under annual costs should state the equipment/parts that were considered and rationale for this determination. The same for Operation and Maintenance costs. The amortization rate should be stated.

10. The formal locking protocol needs to be refined so as to minimize the time at which locking is necessary, especially the basin side lock. Significant safety problems exist with the pedestrian walkway. Consideration should be given to upgrading safety features especially for the suggested nighttime fish locking operations. The walkway is heavily travelled by people commuting back and forth between Boston and Charlestown.

11. The Corps should consider some interpretive signage so that the reasons for the fish ladder, how it works and pertinent regulations as to the taking of fish can be explained to the public.

12. What would be the probable schedule of events for this project once an acceptable plan is agreed to ?

PJD/cmf

wp:CRDCMTS

APPENDIX B

HYDRAULIC ANALYSIS FISH PASSAGE FACILITY

TABLE OF CONTENTS

LIST OF FIGURES

HYDRAULIC ANALYSIS
CHARLES RIVER DAM
FISH PASSAGE FACILITY

1. ABSTRACT

The Charles River Dam Fish Passage Facility has not been fully operable since completion of construction in 1979. The fishway was designed to function under two modes of operation depending on tide levels in the harbor; gravity flow during low tides and pumped flow during high tides. The gravity flow section is currently only partially operable providing very little attraction water at the fishway entrance, and the pumped flow section has never been operable. This hydraulic analysis was conducted to identify approximate velocities expected at the fishway entrance under each of the two different modes of operation assuming that each respective mode is made fully functional. Computed velocities at the entrance and throughout the restored fishway are expected to be of satisfactory magnitude to attract fish into the fishway and upstream through the tidal barrier formed by the dam. These velocities are approximations based on model studies and estimated losses through the passage.

2. INTRODUCTION

The Charles River Dam is located on the Charles River near the Warren Avenue bridge between the Charlestown and North End sections of Boston, Massachusetts. The dam forms a tidal barrier between Boston Inner Harbor and Charles River creating a body of water which extends 8.6 miles upstream to the Watertown Dam. This section of river is referred to as the Charles River Basin. The dam spans 560 feet across the Charles River and consists of a pumping station, navigation locking facilities, and a combination sluiceway/ fishway structure (see Figure 1). The fishway, located at the north end of the dam, was designed to provide passage of anadromous fish, principally shad and alewives, from Boston Harbor upstream through the dam. The passage consists of gravity and pumped flow sections which function separately depending on tidal elevations in the harbor. The gravity flow section operates when the tide level is below the basin elevation while the pumped flow section operates during higher tides.

The fishway has not been fully operable since being constructed in 1979; in fact, most fish pass through the dam via the locks during navigation operations, or "random" fish locking procedures. The gravity flow section is currently only partially operable providing very little attraction water at the downstream end of the fishway (harbor entrance), and the pumped flow section has never been operable.

A further inadequacy of the fishway is its inability to pass smelt, although smelt passage was considered in the original design according to the Charles River Dam Operation and Maintenance Manual (July 1979). For some undetermined reason the smelts will not go

through the fish ladder, but apparently pass through the locks during lock operations instead.

As a result of the above deficiencies, improvement of fish passage at Charles River Dam is being evaluated under Section 1135 authority of the 1986 Water Resources Development Act. The following options to improve fish passage at Charles River Dam are under evaluation for this study. The first is to close the fishway completely and rely on the present mode of operation of using the navigation locks for fish passage. The second option is to close the fishway, but enhance passage of fish through the navigation locks. The third is to rehabilitate only the gravity flow system. The final option is to renovate the entire fishway, both gravity and pumped flow systems. The third and last options include establishing a formal procedure for passing fish through the locks as well. This hydraulic analysis includes velocity estimates at the harbor entrance and at other key locations throughout the fish passage facility at various tide elevations for these last two improvement options.

3. DESCRIPTION OF FISHWAY ELEMENTS

This facility consists of 29 fishbays connected by vertical slots, which provide fish passage from an entrance in the harbor at the downstream face of the dam to either (a) a false weir with an exit chute to the basin at bay 29 on the upstream face, or (b) a sluice gated channel connecting bay 17 to the basin. Plan and elevation views of the fishway are shown in Figures 2 and 3, respectively. The following paragraphs identify fishway operation per original design.

The fishway sluice channel is used during low (harbor) tides providing gravity flow freshwater to the fishway and a route for fish from bay 17 to the basin. The basin is normally maintained at 108 feet Metropolitan District Commission datum (MDCD) and the sill of the fishway sluice gate is at elevation 105 feet MDCD. The gravity flow system was originally designed to operate at harbor tide elevations below 104.6 feet MDCD. Above this tide level, velocities at the harbor entrance were believed to decrease significantly as a tide elevation of 106 feet MDCD is approached, at which estimated velocities were practically negligible. At higher tide levels a float-activated switching mechanism is supposed to turn on the fishway pump and close the fishway sluice gate. This would cause attraction water discharge at the false weir and divert migrating fish away from the fishway sluice channel, into bay 18, and up to the false weir. The top of the false weir is at elevation 114.3 feet MDCD.

The fishway's harbor entrance is a slot with a sill elevation at 96.0 feet MDCD. A 3-foot wide floating weir located in the slot and ballasted to float with its crest 2.5 feet below harbor level automatically controls the velocity of flow. A constant flow area of 7.5 square feet is maintained by this weir at all tide levels above elevation 98.5 feet MDCD. A minimum flow area of 6 square feet is provided at extreme low tide elevation 98.0 feet MDCD.

The fishbays are basically rectangular in plan with chamfered corners. The slots connecting the bays are formed by overlapping walls of adjacent bays, varying in area to

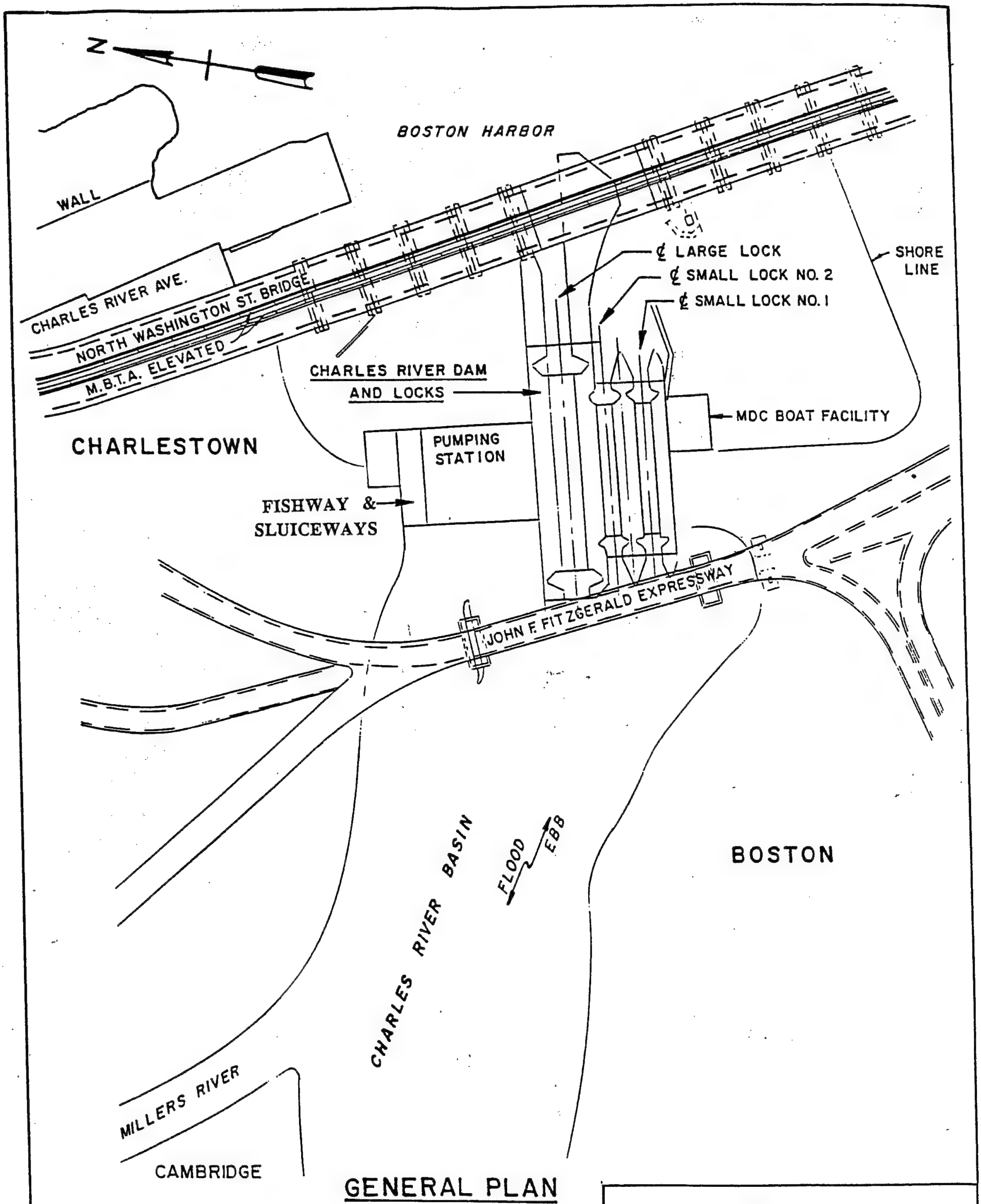
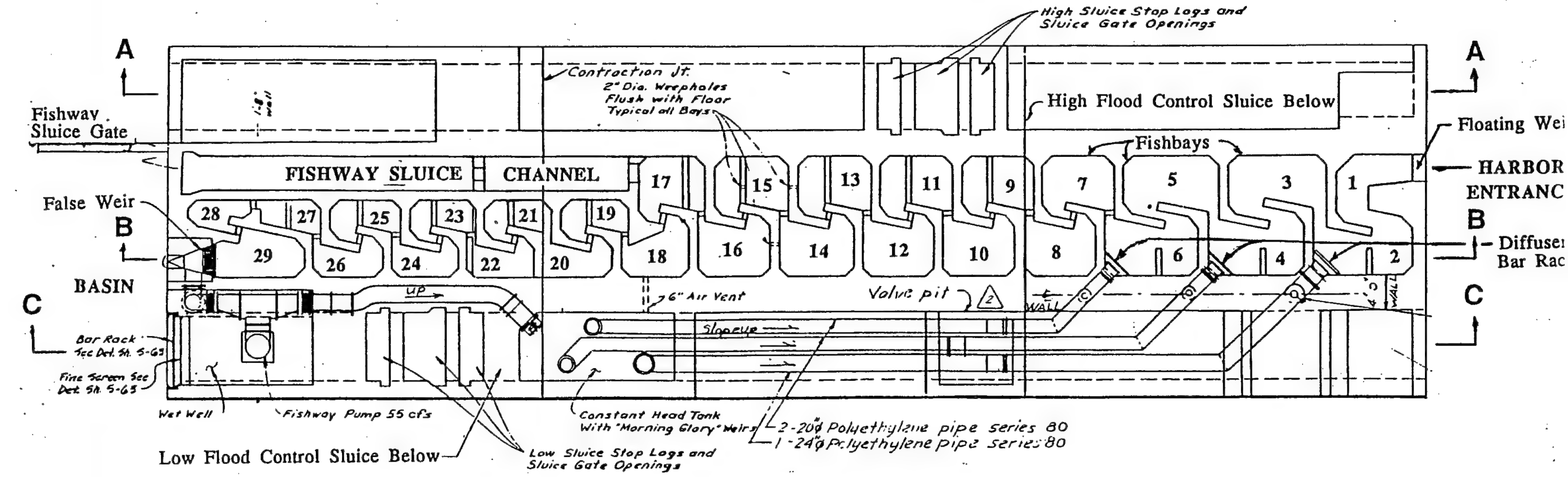
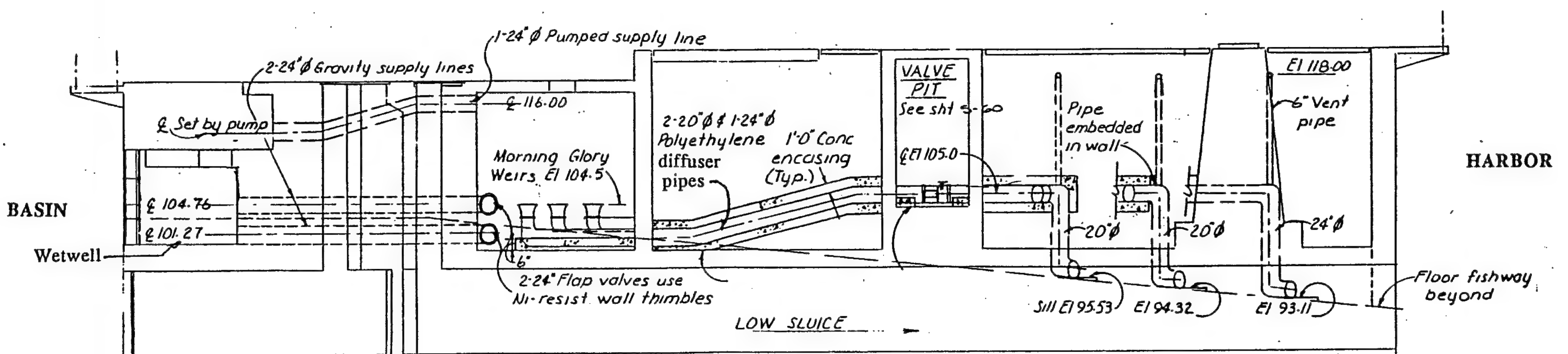


FIGURE 1

CHARLES RIVER DAM



OVERALL LAYOUT OF HYDRAULIC SYSTEMS
WITH CONCRETE COVER REMOVED FOR VIEWING



HYDRAULIC PROFILE-PIPING

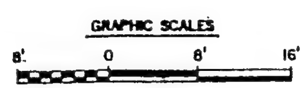
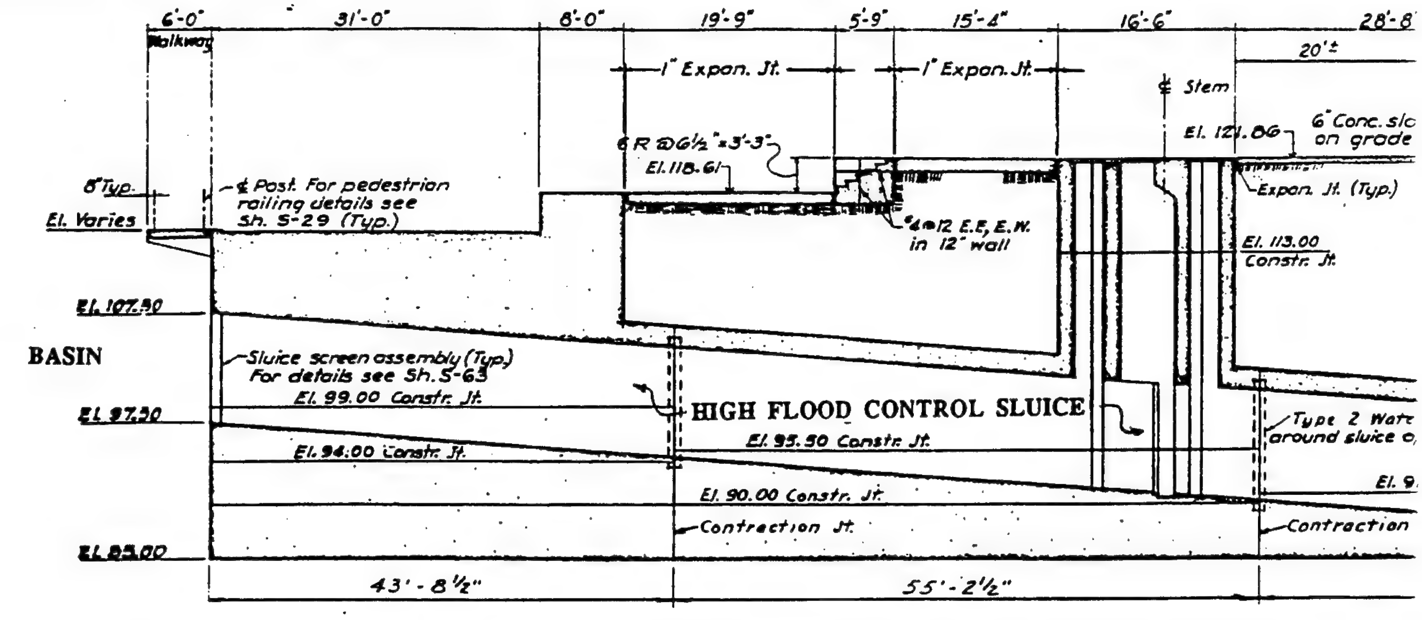
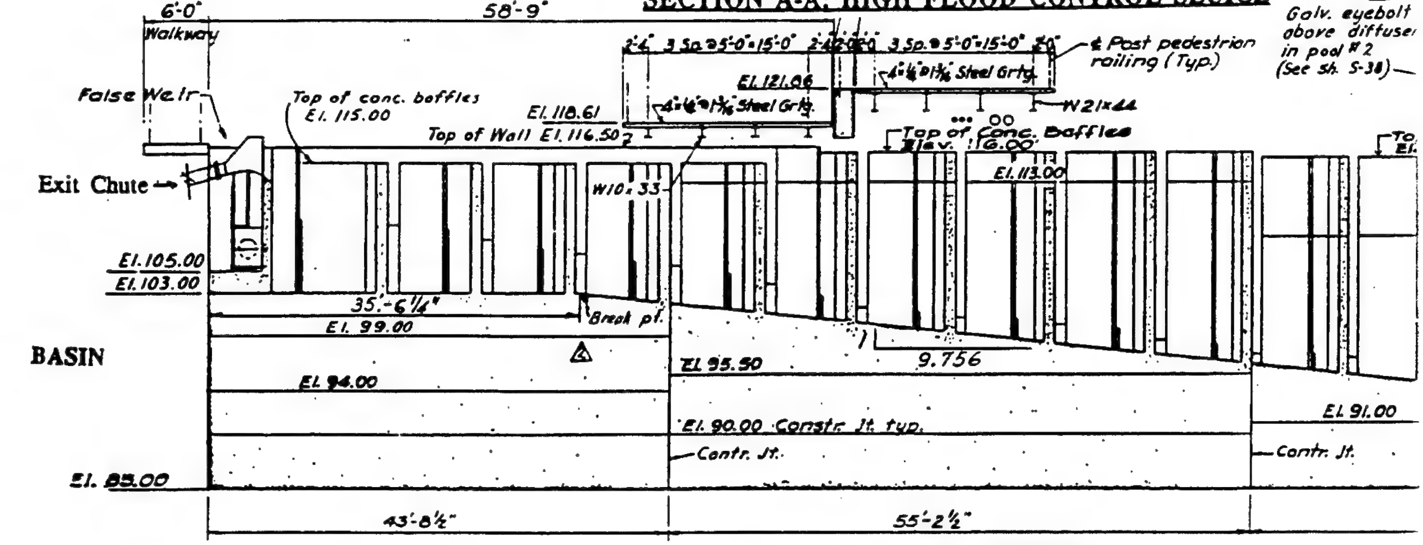


FIGURE 2
CHARLES RIVER DAM
FISHWAY PLAN
AND PIPING PROFILE

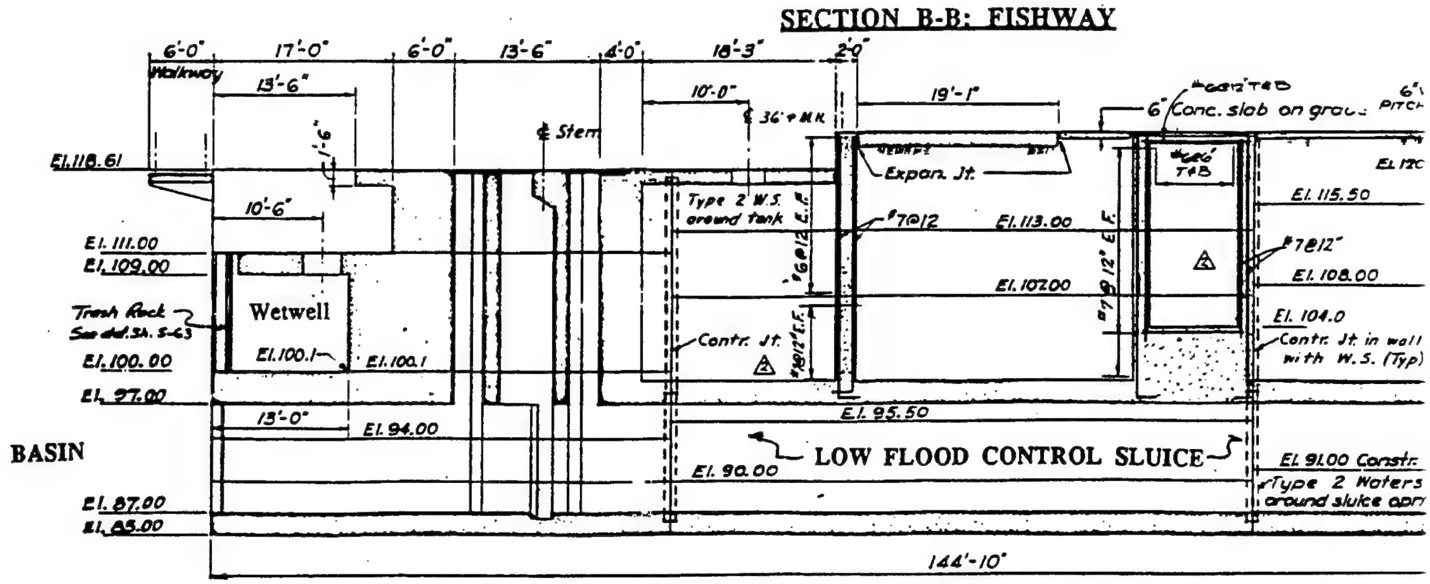
FIGURE 2



SECTION A-A: HIGH FLOOD CONTROL SLUICE



SECTION B-B: FISHWAY



SECTION C-C: LOW FLOOD CONTROL SLUICE

1

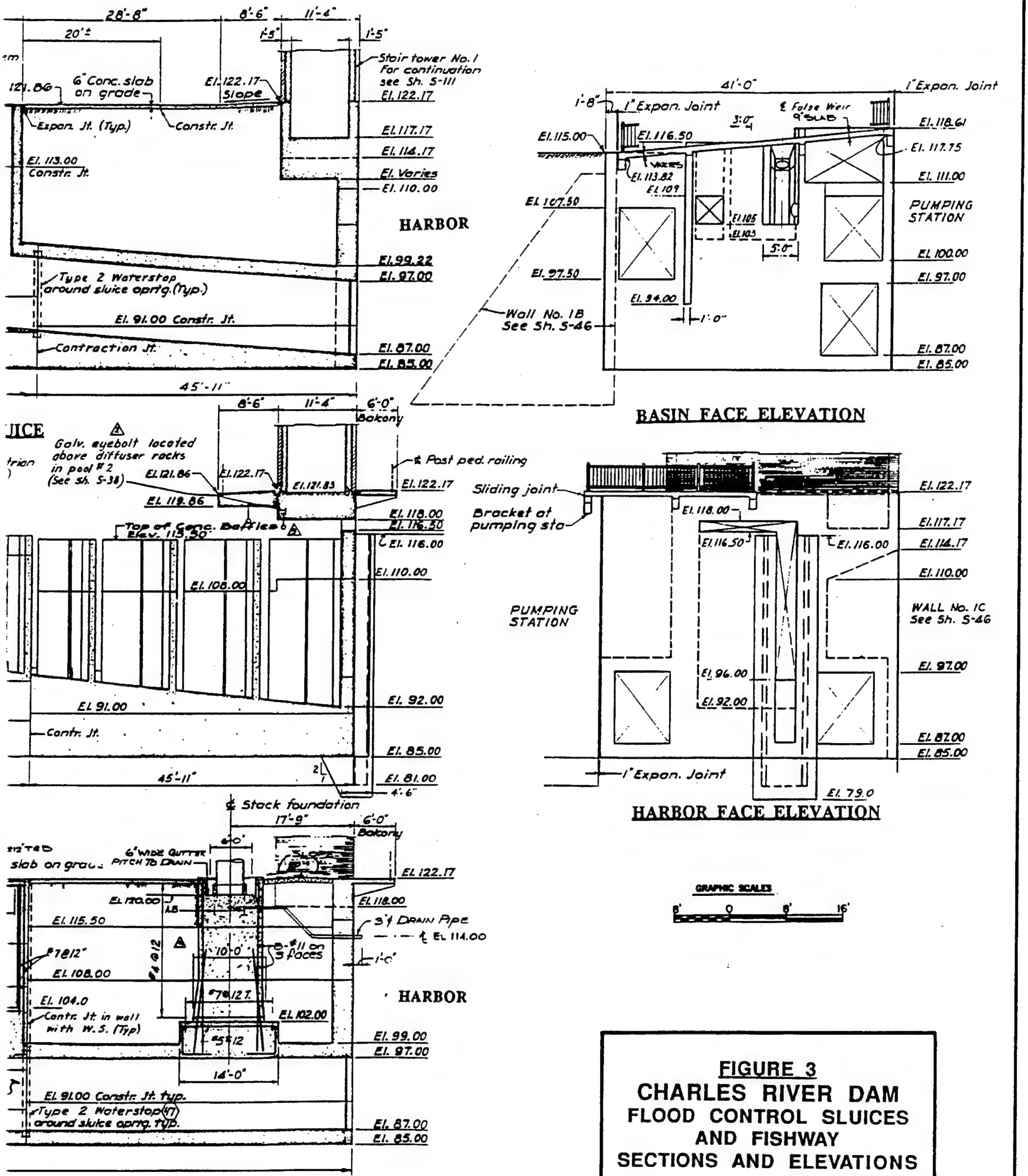


FIGURE 3
CHARLES RIVER DAM
FLOOD CONTROL SLUICES AND FISHWAY
SECTIONS AND ELEVATIONS

regulate the flow velocity. Slots at bays 2 through 6 extend full depth to the floor with no sills and various widths. The others are set at the minimum width of 1 foot and have sills of varying elevations to reduce the flow area. The fishway floor slopes from elevation 92.0 at the downstream end of the ladder to elevation 103.0 feet MDCD at bays 22 and 23 and in the fishway sluice channel. Twelve bays have low sills within them and bay 1 has a wall deflector. These features and the corner chamfers direct the flow into a nearly horizontal path and prevent upwelling along the walls.

The vertical mixed flow fishway pump is a one-stage propeller type, driven by an electric motor rated 150 HP at 700 RPM. The original design specified a flow rate of 50 cfs, however, the pump that was actually installed had a flow rate of 55 cfs with a 16-foot total dynamic head (TDH). Although the pump is no longer in place, it was designed to draw water from a wet well connected directly to the basin and separated by a bar rack and screen. Water flows from the wet well to a constant head tank by gravity supply lines during low tides and by pump operation during high tides. From the constant head tank, water flows by gravity through two 20-inch and one 24-inch diameter polyethelene pipes to bays 2, 4, and 6 at the downstream end of the fishway. This system introduces additional water for attraction flow at the entrance during all modes of operation. Diffuser bars are attached to the ends of each pipe and diffuser bar racks are attached to the walls of each pool at the pipe outlets to redirect the flow path (see Figure 4). The pipe diffuser bars consist of horizontal bars skewed downward 45 degrees to direct the inflow into the bar rack diffuser well without causing upwelling. The bar racks are vertical baffles skewed 45 degrees to direct the flow into the normal flow path along the walls and attract fish across the grill.

4. BACKGROUND

Present operational condition of the fish passage is hampered by malfunctioning or missing elements. Problems with the fishway may have originated during or soon after its construction. The pump system was tested following construction of the facility. Results of the tests indicated the diffuser pipes were clogged, as they were incapable of handling flows generated by the fishway pump. The pump motor burned out during testing operations, most likely due to debris lodged in the pipes. The fishway pump and motor have since been removed for repair, but have not been repaired nor replaced to date.

As part of this study, the fish passage facility was dewatered and inspected to determine the extent of damage to the different elements. During this investigation the pipe system was cleared of debris which had accumulated at the end near the diffusers. Also, the diffusers, originally attached to the ends of each pipe, are missing but the diffuser bar racks remain secured in bays 2, 4, and 6. Other elements of the fishway in disrepair include the floating weir, trash collection, and dewatering systems. The floating weir sunk with its crest at elevation 96 feet MDCD, significantly increasing flow area and reducing attraction velocities at the fishway entrance under most flow conditions. A 1/4-inch mesh trash collection screen located in front of the wet well is missing, causing much debris to enter and accumulate within the piping system. Accumulation of debris within the pipes reduces flows

to pools 2, 4, and 6. The dewatering system is also in poor condition, and most of the stoplog guides are either missing or are too corroded to support the stoplogs.

5. HYDROLOGIC CONDITIONS

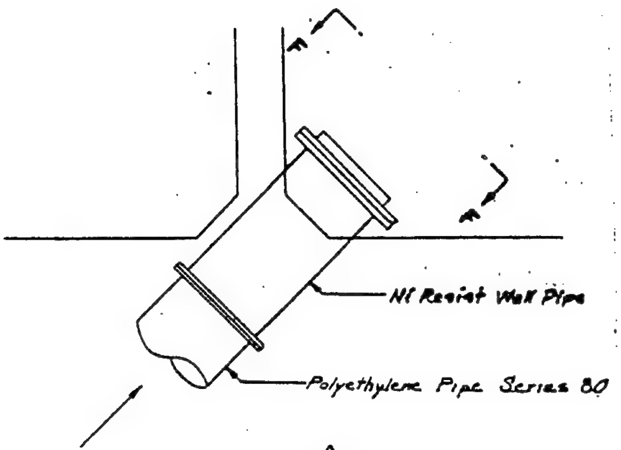
Drainage area at the new Charles River Dam is 309 square miles. Water surface elevation on the basin side of the dam is maintained at approximately 108 feet MDCD. At the National Ocean Survey tide gage in Boston, Massachusetts (the nearest one to the study area), the mean range of tide and the mean spring range of tide are 9.5 and 11.0 feet, respectively. However, the maximum and minimum predicted astronomic tide ranges at Boston have been estimated at about 14.7 and 5.0 feet, respectively, using the Coastal Engineering Research Center (CERC) report, entitled "Tides and Tidal Datums in the United States", SR No. 7, 1981. Mean tide level is at MDCD elevation 105.9 feet. Tidal datum plane relationships estimated for the Charles River Dam are shown in Figure 5. Tide level in the harbor is less than the basin elevation of 108 feet MDCD approximately 60 percent of the 24-hour and 50-minute (approximate) tidal day based on a complete mean tidal cycle for this area.

The nearest U.S. Geological Survey gaging station is located about 12 miles upstream from the dam on the Charles River at Waltham, Massachusetts. Average monthly flows during the spring fish migration season measured at this gaging station for the period of record (1931-1990) are 629, 606, 362, and 240 cfs for March, April, May and June, respectively. Drainage area at the gaging station is 227 square miles, or about 73 percent of the total 309 square mile watershed at the dam. Based on drainage area ratios, flows near the dam are expected to be at least 24 percent larger.

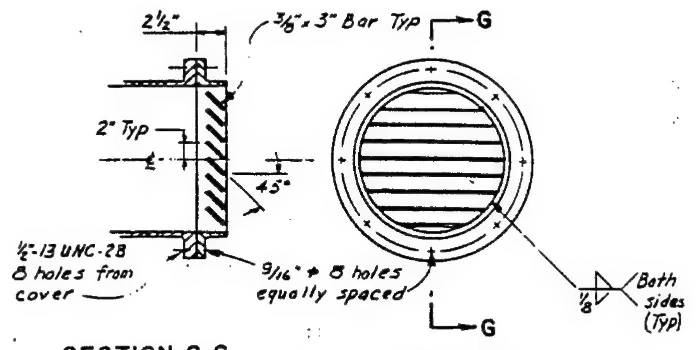
6. HYDRAULIC ANALYSIS

a. General. Hydraulic analysis of the fishway includes evaluation of attraction velocities provided at its entrance for the following fish passage improvement options. The first is to renovate only the gravity flow section, including rehabilitating the floating weir, installing new stoplog guides, cleaning gravity lines and diffuser pipes, and renovating the trash collection system. The other option is to rehabilitate the entire fishway which includes the above renovations as well as installing a new pump system.

Freshwater attraction flows near the harbor entrance to the fishway are provided by the fish passage as well as by the low and high 8 by 10-foot flood control sluiceways. These sluiceways are located adjacent to and below the fish passage facility (see Figures 2 and 3). A rating curve from the Charles River Dam Operations and Maintenance Manual shown in figure 6 identifies expected flows versus tide elevations at the high and low sluice outlets with the gates fully open. Maximum flows from these sluiceways would occur at the lowest predicted astronomical tide elevation, about 98.5 feet MDCD. At this tide level and a



DIFFUSER DETAIL ⚠1

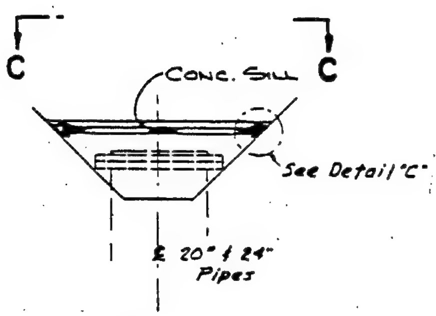


SECTION G-G

VIEW F-F

NOT TO SCALE

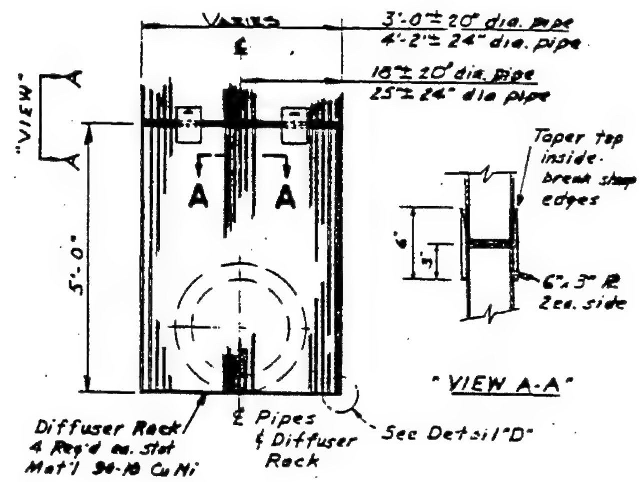
PIPE DIFFUSER BARS



PLAN

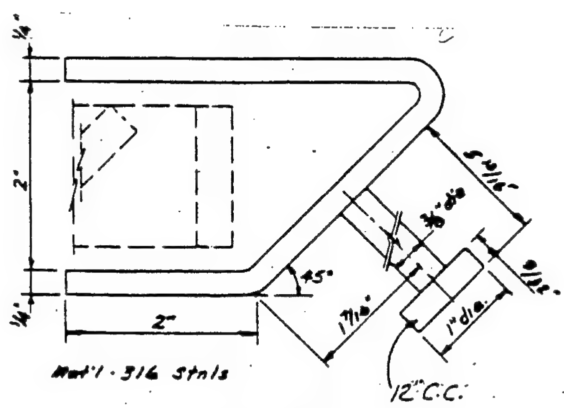
DIFFUSER RACK

NO SCALE



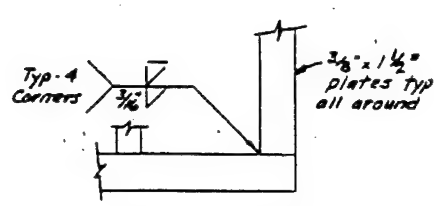
ELEVATION C-C

NO SCALE



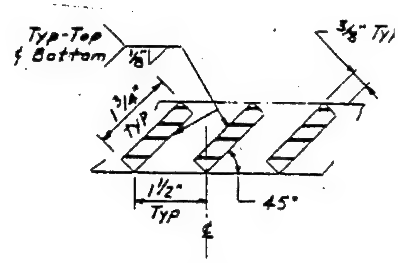
DETAIL "C"

FULL SCALE.



DETAIL "D"

FULL SCALE



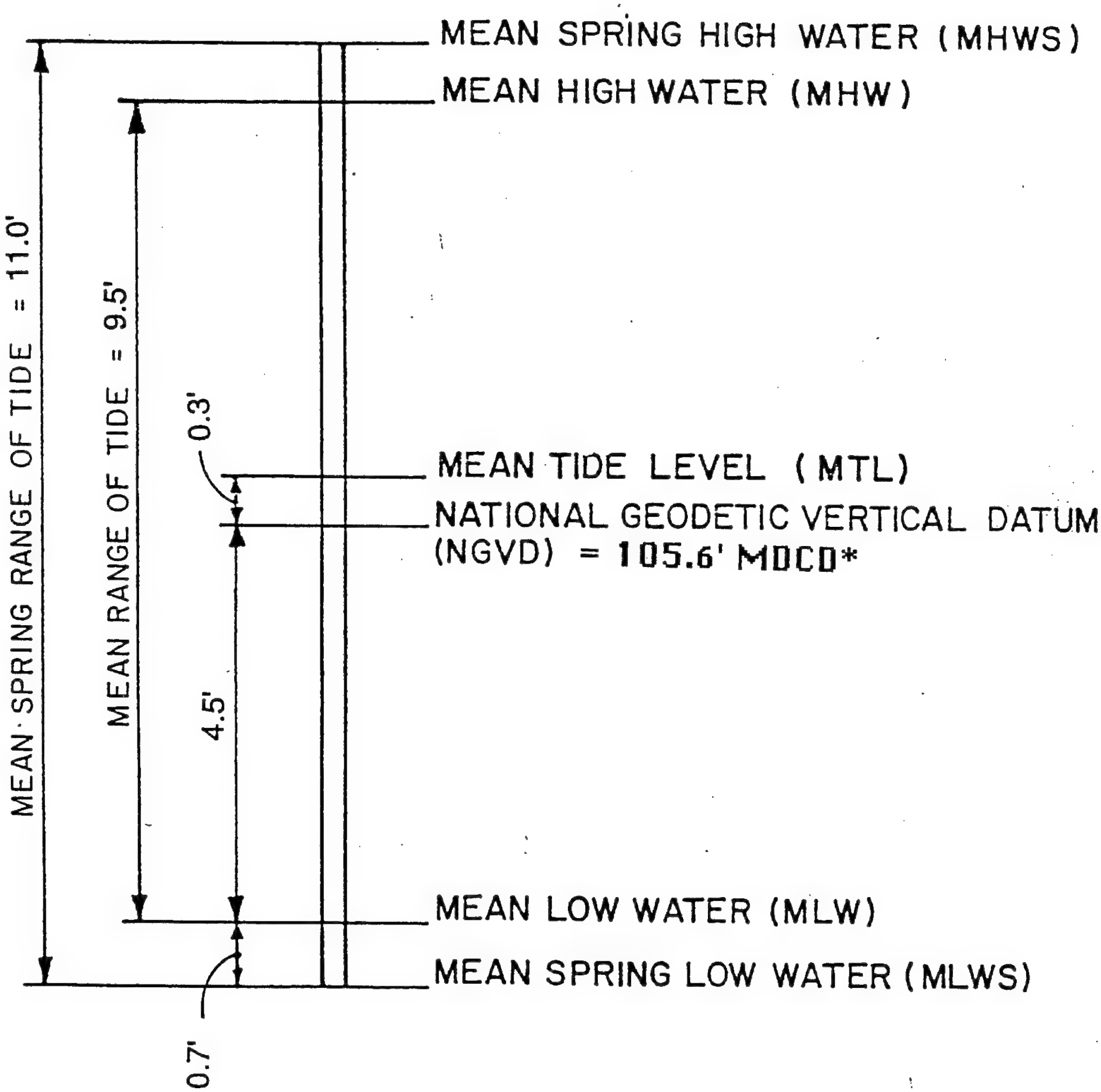
SECTION A-A

DIFFUSER BAR RACK

FIGURE 4

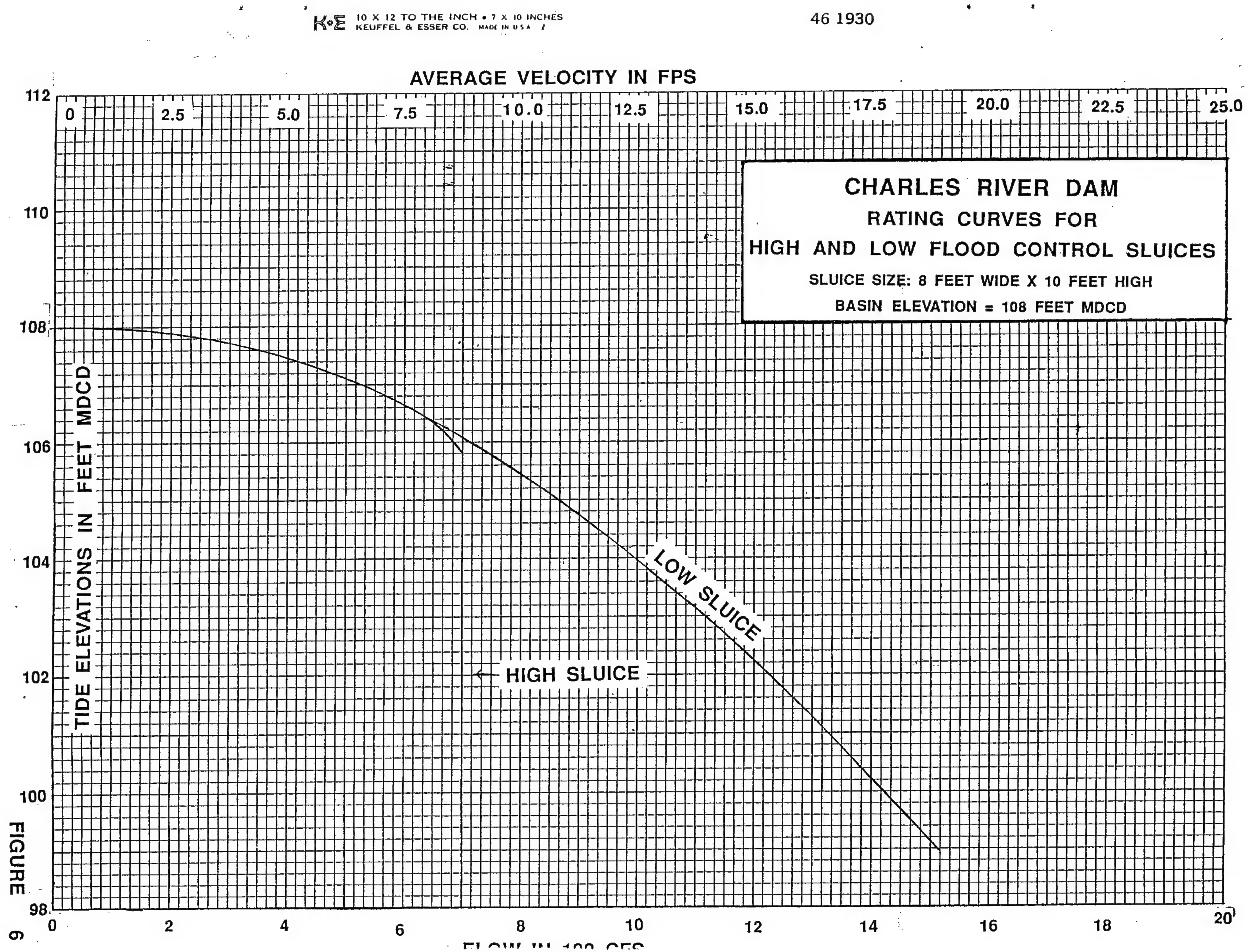
APPROXIMATE TIDAL DATUM PLANES
BOSTON, MASSACHUSETTS AT CHARLES RIVER DAM

(BASED UPON CURRENTLY AVAILABLE, SHORT TERM, NATIONAL OCEAN SURVEY TIDAL BENCHMARK DATA FROM 1960-78 TIDAL EPOCH)



*MDCD = METROPOLITAN DISTRICT COMMISSION DATUM

FIGURE 5


K+E 10 X 12 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 1930
AVERAGE VELOCITY IN FPS
0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
CHARLES RIVER DAM
RATING CURVES FOR
HIGH AND LOW FLOOD CONTROL SLUICES
SLUICE SIZE: 8 FEET WIDE X 10 FEET HIGH
BASIN ELEVATION = 108 FEET MDCD
TIDE ELEVATIONS IN FEET MDCD
112
110
108
106
104
102
100
98
LOW SLUICE
← HIGH SLUICE
0
2
4
6
8
10
12
14
16
18
20
FIGURE 6

normal basin elevation of 108 feet MDCD, flows from the high and low sluice are about 700 and 1,550 cfs, respectively. Corresponding average velocities are about 9 and 19 fps through the high and low sluice, respectively. Flows for fully open gates are much higher than normal riverine flows discussed in section 5, and, of course, flows would be less with partial gate openings. Gate openings at any time are dependent on riverflow and the need to maintain the basin at elevation 108 feet MDCD. Also, averagevelocities would be higher when basin elevations are greater than 108 feet MDCD, and lower when basin level is below this elevation.

In the following sections, average velocities expected at various locations in the fish passage facility are identified separately for gravity and pumped flow conditions. Average velocities for pumped flow conditions are based on a model study of the original fishway design conducted by the North Pacific Division Hydraulic Laboratory in Bonneville, Oregon in coordination with the U.S. Fish and Wildlife Service entitled "Fish Ladder for Charles River Dam," dated December 1977. This study identified measured velocities in each fishway pool and at the entrance during pumped flow operation.

Since a detailed evaluation of the pipe network system was not included as part of this study, flows from the diffuser pipes into bays 2, 4, and 6 were assumed to be 15, 10, and 10 cfs, respectively, for the model. Also, very little modeling of gravity flow operation alone was performed for the laboratory study. Consequently, estimated average velocities for gravity flow operation are approximations as it is impossible to make refined estimates of losses through the fishway pools to determine flows and corresponding velocities without performing a detailed model study. However, even refined results of the model study are also approximations, and actual velocities in the fishway may somewhat differ. Although model studies increase the reliability of estimates, the surest indicator of velocity would be actual measurements in the prototype, if that degree of accuracy is essential.

b. Gravity Flow. Gravity-supplied freshwater flow enters the fishway in two areas - at the fishway sluice channel which has a 105-foot MDCD invert elevation and through two 24-inch diameter polyethylene gravity flow lines, with wet well inverts at 103.8 and 100.3 feet MDCD, which discharge to the constant head tank (see Figure 2). This 18-foot high tank supplies water to three auxiliary flow diffuser pipes that discharge into fishbays 2, 4, and 6. The diffuser pipe connecting the constant head tank to pool 2 is 24 inches in diameter, and the pipes supplying pools 4 and 6 are both 20 inches in diameter. These pipes provide gravity flows at discharge velocities which could reach as high as 12 fps each into pools 4 and 6 and 22 fps in pool 2 at basin and harbor elevations of 108 and 98.5 feet MDCD, respectively. This upper limit estimate is strictly an approximation and assumes valves are fully open, pipe diffuser bars are removed, diffuser bar racks remain in place, pipes are clear of debris and other flow area restrictions, and the harbor is at a very low tide. These flows of approximately 46 cfs are in addition to the flow entering the facility from the fishway sluice channel.

The 1977 Hydraulic Laboratory study modeled the gravity flow system exit channel with its sluice gate sill elevation at 106 feet, basin elevation of 108 feet, and tide elevation of

98.5 feet MDCD, producing a flow of 23 cfs through the sluiceway. Note the model's sluice gate sill elevation is 1 foot higher than the actual sill elevation of 105 feet MDCD. Also, the model did not account for backwater due to gravity flows entering pools 2, 4, and 6 from the diffusers. These flows would increase water surface elevations throughout the fishway which would decrease flow at the exit channel sluiceway. In the absence of more accurate data, however, a 23 cfs flow through the sluiceway seems to be a reasonable estimate.

In consideration of both gravity flow from the exit channel and diffusers in pools 2, 4, and 6, maximum average velocities at the fishway entrance could reach about 9 fps (approximate flow of 69 cfs) when the tide is low at elevation 98.5 feet MDCD and assuming flow area is 7.5 square feet. These entrance velocities will decrease to zero as the tide rises to meet the basin elevation of 108 feet MDCD. Maximum computed average velocities versus tide levels are shown on the rating curve in Figure 7. Once again, this rating curve is an approximation, and shows the maximum expected theoretical average velocities provided there are no obstructions in the fish passage and piping system. Again, actual field measurements would be the most reliable indicator of velocity.

As mentioned previously, the tide level in the harbor is lower than the basin elevation approximately 60 percent of the time. However, gravity flow entrance velocities are only acceptable for fish migration when the tide is below 106 feet MDCD (with basin elevation 108 feet MDCD). At these harbor and basin elevations, velocities at the harbor entrance fall below 4 fps, the minimum entrance velocity for fish attraction (according to the Corps of Engineers "Fisheries Handbook of Engineering Requirements and Biological Criteria" written by Milo C. Bell, dated 1986). Consequently, if only the gravity flow system is rehabilitated, the fishway would be effective when the tide is below 106 feet MDCD or about 55 percent of the time (based on the average amount of time the tide is below 106 feet MDCD during the tidal day). In addition, if the floating weir were to remain at a fixed elevation, gravity flow operation of the fish passage would be restricted to a much smaller time period. With a fixed, instead of floating, weir, the flow area will increase rapidly as the tide rises reducing velocities at the entrance.

If only the gravity flow system is renovated and the pump system is abandoned, debris will likely accumulate in the pipe system at a more rapid rate. During gravity flow operation, as the tide approaches the basin elevation velocities within the pipes gradually decrease allowing suspended solids to settle. These settled materials will not likely be easily eroded during the falling tide, since greater velocities are required to scour away deposition than to keep particles in suspension. This may increase maintenance required to clean the pipes. If the pump system is renovated, however, the sudden increase in velocity provided when the pump activates would more easily flush sediments and other buildup from these pipes.

c. Pumped Flow. According to the original design, the pump should operate when the tide rises above an elevation at which gravity flow velocities would become negligible with respect to fish migration, at approximately 106 feet MDCD. The fishway sluice gate would then be closed and the pump activated. Pump discharge is divided at the 30-inch diameter

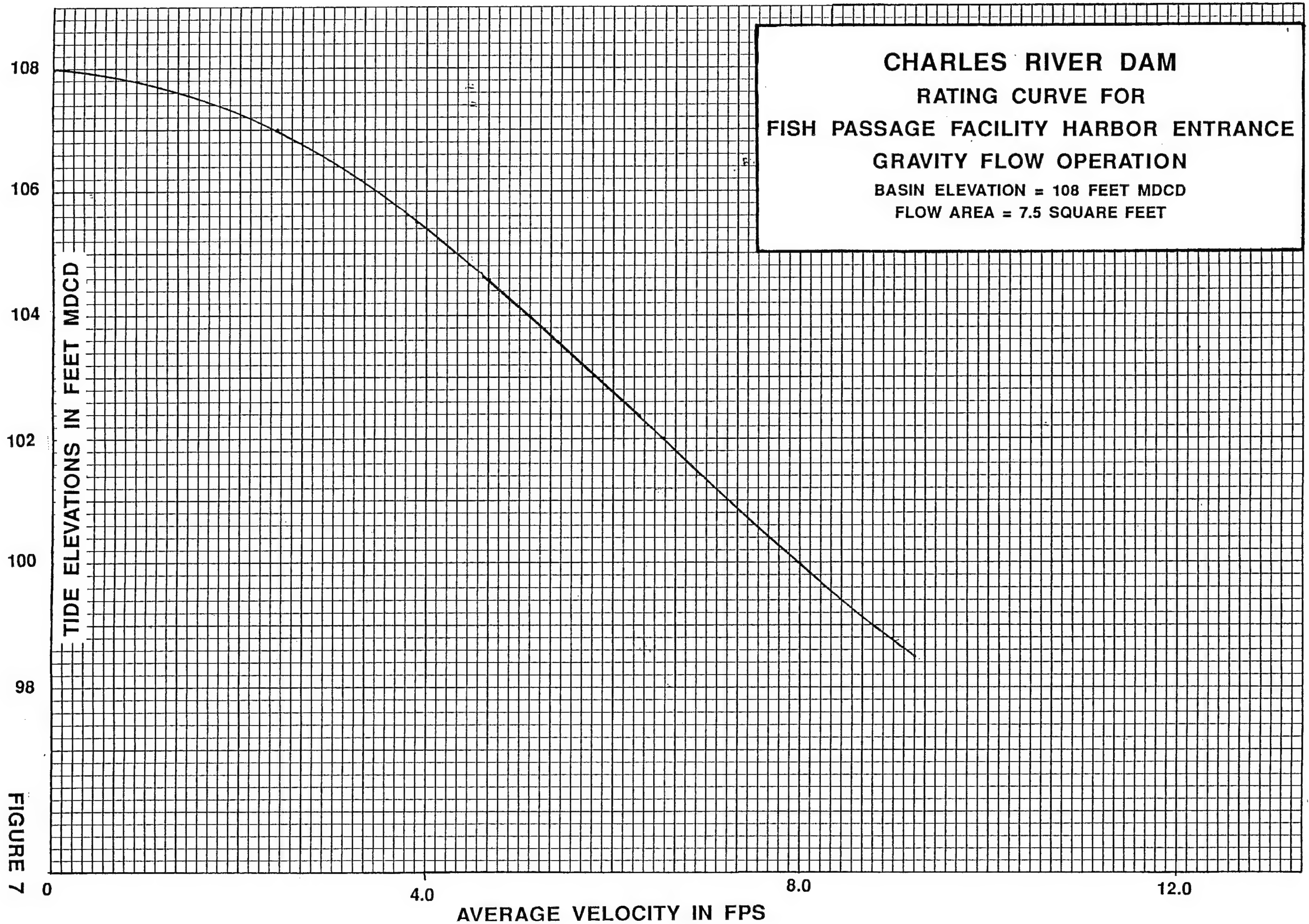

CHARLES RIVER DAM
RATING CURVE FOR
FISH PASSAGE FACILITY HARBOR ENTRANCE
GRAVITY FLOW OPERATION
BASIN ELEVATION = 108 FEET MDCD
FLOW AREA = 7.5 SQUARE FEET
TIDE ELEVATIONS IN FEET MDCD
108
106
104
102
100
98
0
4.0
8.0
12.0
AVERAGE VELOCITY IN FPS

FIGURE 7

tee (see Figure 2) with at least 15 cfs going to the false weir; thereby, providing flow down the fishway and attraction water at the basin in place of that from the gravity-supply exit channel. Approximately 35 cfs is discharged to the constant head tank in which the water level rises sufficiently to allow for a steady state 35 cfs flow through the auxiliary flow supply pipes to pools 2, 4, and 6. According to the description of the original design in the Operations and Maintenance Manual, the water surface elevation in the constant head tank should be approximately 3.6 feet higher than the tide level under this condition. The butterfly valve on the pipeline leading to the false weir should be set at approximately 45 degrees from the fully open position in order to create about 9.5 feet of head loss, limiting the discharge to about 15 cfs. Similarly, the butterfly valve in the pipes leading to the constant head tank should be set 22 degrees from the fully open position to produce approximately 2.5 feet of head loss at about a 35 cfs discharge. These suggested initial settings and readings are approximations based on estimated head losses in the hydraulic system as per original design.

The 1977 model study measured velocities throughout the fish passage facility during pumped flow operations for tide levels 110 and 112 feet MDCD as shown in figure 8. According to this study, pumped flow yields 50 cfs at the fishway entrance when the flow area is 7.5 square feet, and measured velocities were 8.3 to 8.4 fps.

The original design does not appear to have fully accounted for head losses due to the diffusers, diffuser bar racks, nor accumulation of debris, sediment, slime and barnacles as encountered in the pipes during the dewatering and investigation of the network system. In consideration of the above, head losses would probably be significantly higher in the actual system. Moreover, head loss and water surface elevation at the constant head tank were originally determined based on mean high tide, 110.6 feet MDCD. Water surface elevation in the tank will increase as the tide increases. Since top of the tank is at elevation 117.1 feet MDCD, tide elevations above mean high tide may cause excessive pressures forcing off the manhole cover. Maximum predicted astronomic high tides in excess of 112.6 feet MDCD, or 7.0 feet NGVD, are expected to occur about 15 times a year as shown in figure 9 (based on the 1981 CERC report). Using this tide level and assuming a possible 5-foot head loss in the pipe system between the harbor and constant head tank, water surface elevation in the tank would be higher than its top. Consequently, flow might pass through the manhole at the constant head tank and some would be forced to the false weir. If the manhole were sealed, more flow would be forced to exit through the false weir than through the diffuser pipes during extremely high tides.

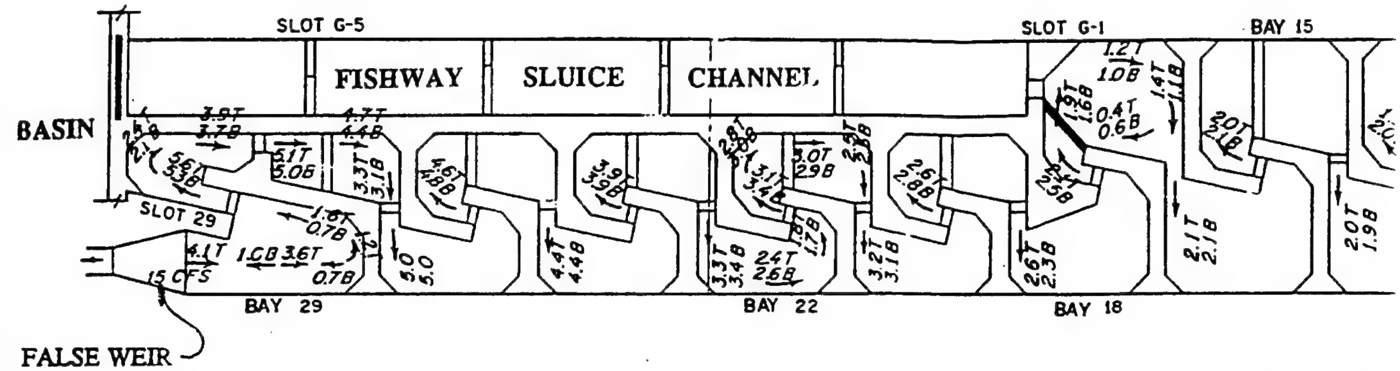
Since pressures in the constant head tank may be excessive during astronomical high tide events, the following alterations should be considered: (1) directly connecting the pump discharge line entering the constant head tank to the three diffuser pipes, creating a continuous and pressurized system, (2) installing a permanent sealed manhole cover and extending the tank vent to an elevation above the expected head, or (3) install a float in the constant head tank that would throttle the pump when a specific water surface elevation is reached in the tank; this may require a variable, instead of a fixed, speed pump.

Another concern with renovating the pump flow system is possible fish kills in the upper bays after termination of pump operation. When the pump turns off and the gravity flow sluice gate opens, most fish in bays 18 to 29 would not be able to find their way back to bay 17 and exit through the gravity flow sluice channel. If many fish are trapped, they may use up the water's dissolved oxygen supply and die before pump operation resumes. To provide oxygenated water to the upper bays under these conditions, a gated opening of approximately 6 inches in diameter could be bored through the concrete between the basin and bay 28 (see Figure 2). This 6-inch diameter gate would be opened when the fishway sluice gate opens. Another method of providing oxygen to these bays is to intermittently turn the pump on and off during gravity operation. In addition, a hydraulically operated screen should be installed between bays 17 and 18 replacing the fixed screen that is presently in place (this fixed screen should remain in place only if the gravity flow system alone is renovated). This new screen would close off bay 18 during gravity flow operation to prevent any more fish from travelling into the upper bays.

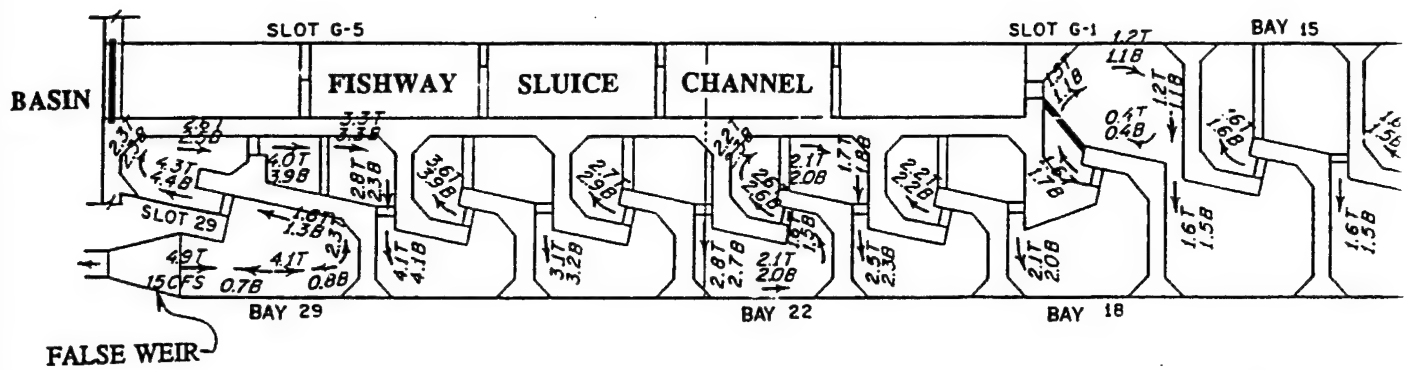
Once in operation, the fishway discharges should be measured and appropriate adjustments made to the valves, if necessary, in order to assure that proper flow rates are being attained. The pipe diffuser bars should not be reinstalled unless significant upwelling occurs in the wells before the bar racks such that fish progress is diminished.

7. CONCLUSION

Based on hydraulic model studies and head loss estimates, both the gravity and pumped flow systems appear to generate sufficient attraction velocities of at least 4 fps at the fishway entrance, and throughout the facility to encourage fish passage. If only the gravity flow system is renovated, entrance velocities above 4 fps could be maintained for effective fish passage about 55 percent of a tidal day. Satisfactory operation of both systems is highly dependent on maintenance, especially trash control. The trash collection system should be renovated, and the log boom at the fishway exit should be replaced with a more efficient one which extends about 4 to 5 feet below the water surface elevation. This system should be well maintained to minimize debris accumulation within the fishway and to prevent excessive head losses in the pipe system. In addition, the pipe system should be cleaned prior to the spring fish runs and the facility dewatered and inspected on a regular basis. It may be advisable to install a dewatering system which would enable dewatering of only that portion of the fishway needed for cleaning the pipes. This may save maintenance costs of dewatering the entire fishway just to clean the pipes. Consideration should be given to covering the fishway with a removable grate or screen to prevent people from throwing material into the fish bays.



TIDE ELEVAT



TIDE ELEVAT

LEGEND

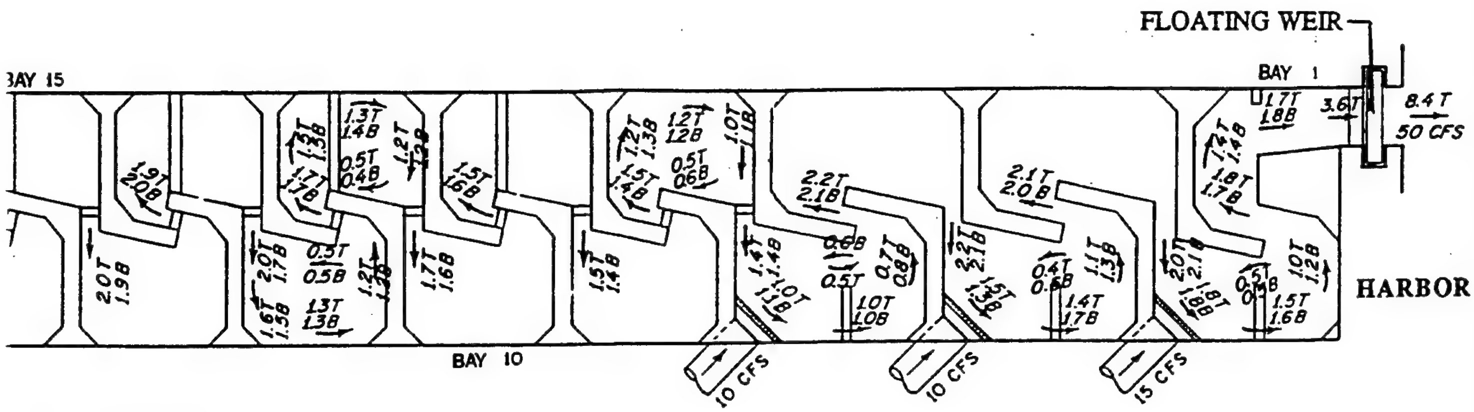
2.4 ← VELOCITIES IN FPS

T 1-FT DEPTH

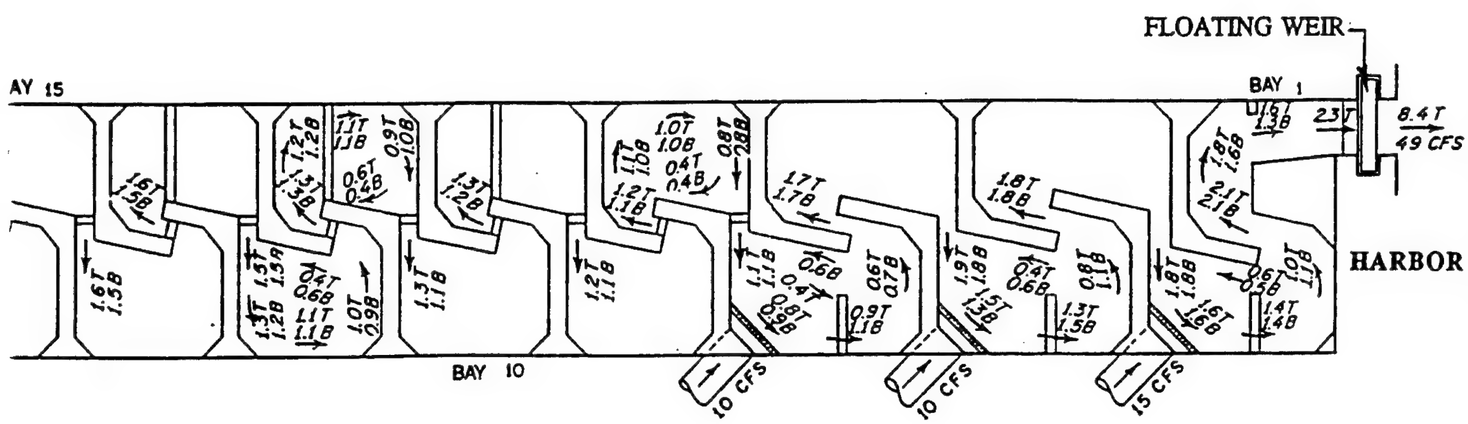
M 4-FT DEPTH

B 7-FT DEPTH OR 1 FT ABOVE INVERT OR SILL OF UPSTREAM SLOT

ELEVATIONS IN FEET MDCD



IDE ELEVATION 110.0



DE ELEVATION 112.0

CHARLES RIVER DAM
FISH LADDER PLAN B
HYDRAULIC MODEL INVESTIGATION
VELOCITIES
TIDE ELEVATIONS 110.0 AND 112.0
RIVER ELEVATION 108.0

FIGURE 8

(2)

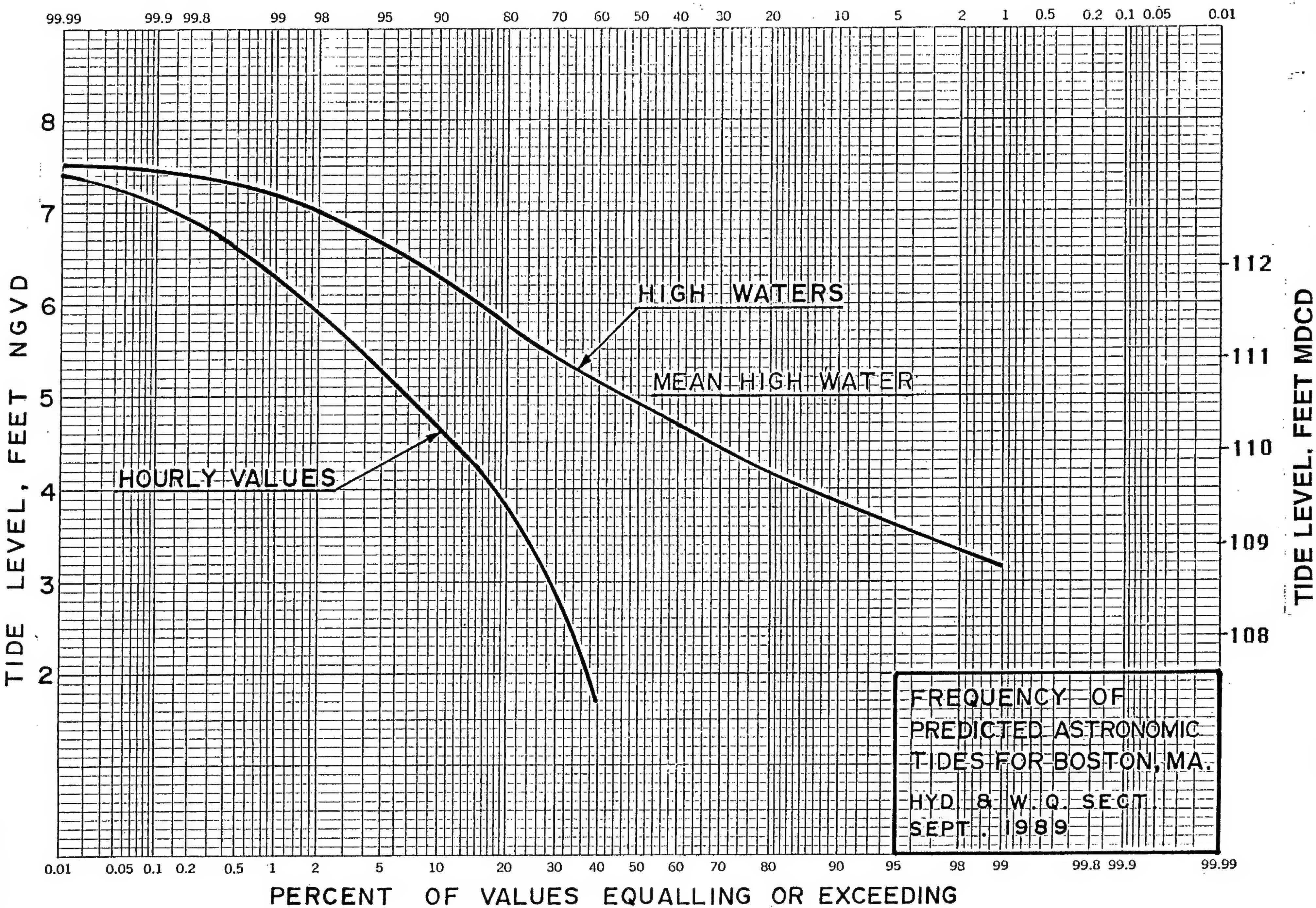

99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
8
7
6
5
4
3
2
TIDE LEVEL, FEET NGVD
HIGH WATERS
MEAN HIGH WATER
HOURLY VALUES
112
111
110
109
108
TIDE LEVEL, FEET MDCD
FREQUENCY OF
PREDICTED ASTRONOMIC
TIDES FOR BOSTON, MA.
HYD. & W.Q. SECT.
SEPT. 1989
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
PERCENT OF VALUES EQUALLING OR EXCEEDING

FIGURE 9

APPENDIX C

WATER QUALITY EVALUATION CHARLES RIVER BASIN

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CHARLES RIVER DAM FISH PASSAGE STUDY

1. ABSTRACT

This report identifies water quality conditions related to improvement of fish passage at the Charles River Dam. This study is authorized under Section 1135 of the 1986 Water Resources Development Act. Water quality of the Charles River near the dam is evaluated to determine the feasibility of various options to improve fish passage. The first is rehabilitating the existing fishway. Water quality concerns of this option include determining the toxicity of water entering the fish passage with respect to fish life and corrosion characteristics of the water with respect to construction materials to be used in the rehabilitation. Another option is to enhance fish passage through increased lock operations. Two major concerns of this option are the quality of the water passed through the locks with respect to fish life, and the effects of additional lock operations on saltwater intrusion upstream from the dam.

The Charles River Basin is the 8.6-mile section of the Charles River located between Watertown Dam and the Charles River Dam, and is herein referred to as the basin. It has a well defined hypolimnium containing highly saline water with low dissolved oxygen and low to high hydrogen sulfide levels. The hypolimnium exists because of saltwater present in the basin. Freshwater overlying the hypolimnium is of fairly good quality.

Since the fishway draws water from the upper part of the water column, water entering the fishway would normally be of good quality with dissolved oxygen levels above the recommended standards. Hydrogen sulfide was measured at the hypolimnium near the dam to identify the water's potential to corrode construction materials. Hydrogen sulfide levels present near the dam are relatively low with a maximum concentration of 0.4 mg/l for 1989 and 1991 data. However, hydrogen sulfide is present in the hypolimnium at higher concentrations upstream from the dam, with a maximum concentration measurement above 26 mg/l.

Fish migration through the dam can be enhanced by passing fish through the navigation locks located at the south end of the dam. Small lock 1 is adequate for this process since fairly good quality water is drawn into this lock.

Use ofthe large lock and small lock 2, however, may not be advisable because poor quality waters are drawn into these locks which may be harmful to the migrating fish. Additional lock operations for fish passage should be limited to operations during low tides to reduce saltwater intrusion into the basin. In this case relatively little saltwater would be passed to the basin, especially since fish passage lock operations would be infrequent as most fish would be locked through during regular navigation operations.

2. INTRODUCTION

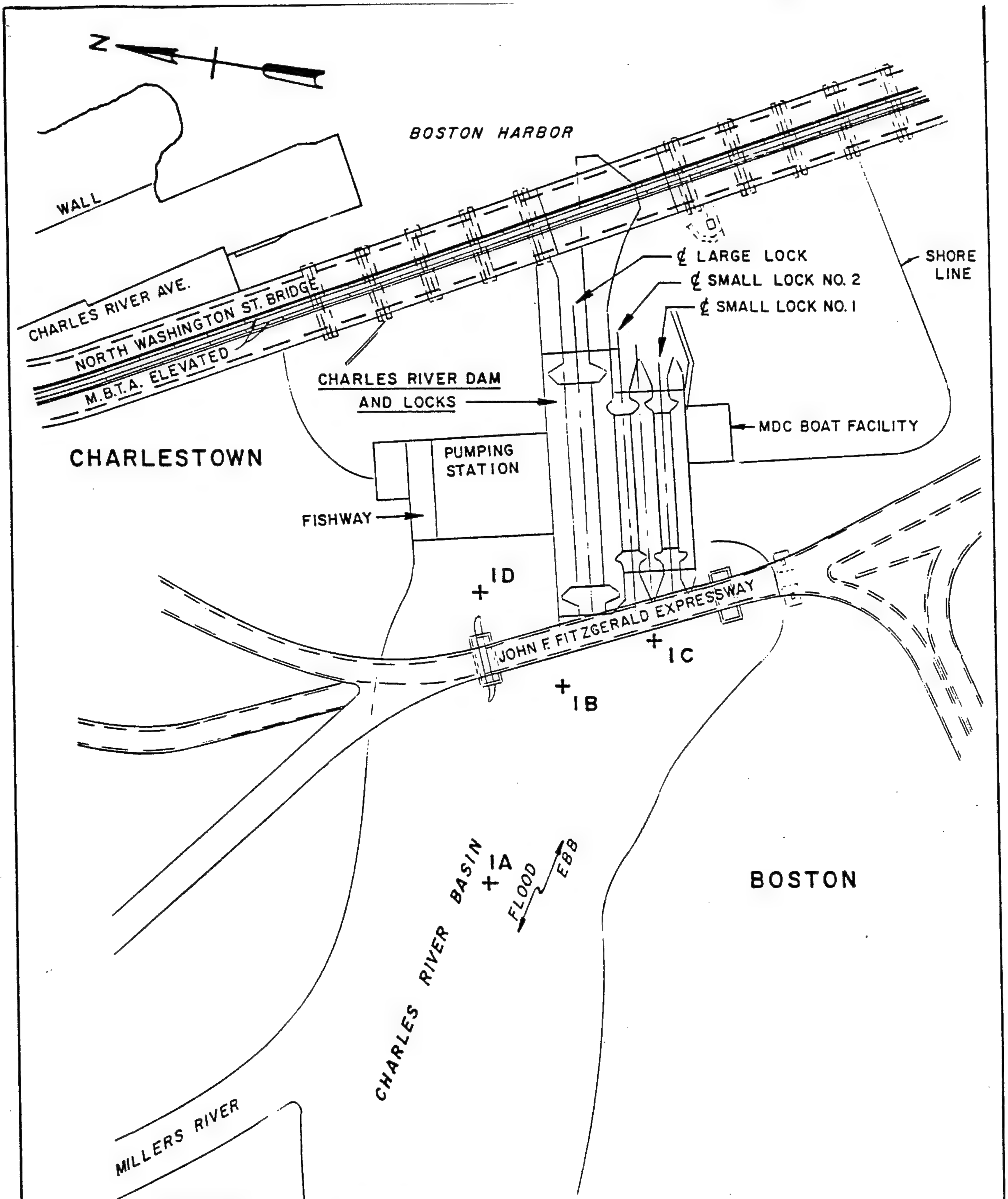
The Charles River Dam is located on the Charles River near the Warren Avenue bridge between the Charlestown and North End sections of Boston, Massachusetts. The dam is approximately 560 feet in length and consists of a pumping station, navigation facilities, and a combination sluiceway fishway structure. The fish passage facility, located at the north end of the dam (see Figure 1), was designed to provide passage of anadromous fish, principally shad and alewives, from Boston Harbor upstream through the tidal barrier formed by the dam. The passage consists of both gravity flow and pumped flow sections. The pumped flow system which was designed for use during high tide has never been operable. The gravity flow system operates during low tide, and currently is only partially operable, providing very little attraction water at the downstream end of the fishway. The fish passage has been very unsuccessful as a result of the above problems; in fact most fish pass through the dam via the locks during navigation operations. A further inadequacy of the fishway is its inability to pass smelts, even though it was designed to pass rainbow smelt. For some undetermined reasons the smelts will not go through the fish ladder, but pass through the locks, during navigation operations instead. Based on the above inadequacies, this study also considered supplementing fish passage by use of the navigation locks.

Water quality conditions in the Charles River near the dam are evaluated for this study to determine the feasibility of various options to improve fish passage. The first is rehabilitating the existing fishway. Related water quality concerns include determining the toxicity of water entering the fish passage with respect to fishlife and corrosion characteristics of the water with respect to construction materials to be used in the rehabilitation. Corrosion characteristics are determined by measuring and evaluating hydrogen sulfide concentrations near the dam. Corrosion of materials is a concern, since according to MDC project personnel, materials at the dam corrode at an extremely rapid rate. Another option is to enhance fish passage through increased lock operations. Two major concerns of this option are quality of the water passed through the locks with respect to fish life, and effects of additional lock operations on saltwater intrusion upstream from the dam.

3. BACKGROUND

The new Charles River Dam replaced the function of the old Charles River Dam which remains situated approximately 2,250 feet upstream at the Science Park. Construction of the new dam was necessary mainly for flood control due to increased peak flows from urban development and for better facilities to handle increased navigation. Improvements at the new dam include the fish passage facility, a pump station designed to pump basin water into the harbor during peak flow periods, high and low sluice gates to facilitate releases during normal flow periods, and three navigation locks designed to facilitate navigation and minimize saltwater intrusion.

a. Fish Passage Facility. This facility consists of 29 pools connected by vertical slots, which provide passage from an entrance in the harbor on the downstream face of the dam



GENERAL PLAN

FIGURE 1

CHARLES RIVER DAM

1991 COE SAMPLING STATIONS
1A - 1D

to either (1) a false weir with an exit chute, or (2) an exit channel with a sluice gated opening to the basin at the upstream face. The false weir/exit chute exit is used during high tides under pumped flow operation, while the exit channel/sluice gate exit is used during low tides under gravity flow operation. The harbor entrance to the fishway is a slot with its sill at elevation 96.0 feet Metropolitan District Commission Datum (MDCD). A 3-foot wide floating weir, located in the slot and ballasted to float with the crest 2.5 feet below harbor level, automatically controls the velocity of flow. The basin exit sluice gate has a sill elevation at 105 feet MDCD and the bottom of the wet well containing the pump has a basin entrance elevation at 100 feet MDCD.

b. Flood Control Sluices. The high and low flood control sluice gates are 8 feet wide by 10 feet high, and are used to maintain the basin elevation at 108 feet MDCD during normal runoff. The high sluice gate is located near the fishway with an invert elevation of 97.5 feet MDCD. The low sluice gate is near the pumping station in the middle of the dam with an invert elevation of 87.0 feet MDCD. Outlets to both sluice gates have invert elevations at 87.0 feet MDCD. Differences in sluice invert elevations allow water to be drawn or released from different parts of the water column. Low level releases made from the low sluice gate induce flushing of the bottom waters from the basin. This is generally desirable since bottom waters in the basin are highly saline and often contain sulfides.

c. Navigation Locks. One large and two small navigation locks are located at the southern end of the dam. The large one is 300 feet long and 40 feet wide, with upstream and downstream sill elevations of 91.0 and 86.0 feet MDCD, respectively, and a floor elevation of 84.0 feet MDCD. Each of the two small locks are 200 feet long and 25 feet wide, with upstream and downstream sill elevations of 100.0 and 94.0 feet MDCD, respectively, and a floor elevation of 92.0 feet MDCD.

All navigation gates at the locks are sector type gates. During locking operations, water in the locks is filled or drained by north and south culvert gates located at both ends (upstream and downstream) of each lock. On the basin side (upstream), the culvert gates are located at elevations 93.25 and 88.0 feet MDCD for small lock 1 and the large lock, respectively. On the harbor side, culvert gate inverts are also at 93.25 feet MDCD for small lock 1, but are at 85.0 feet MDCD for the large lock. Small lock 2 is between the other locks. Its south culverts are at the same elevation as small lock #1 culverts, but its northern culverts connect to the large locks south culverts.

Although locking operations at the new dam have significantly improved from the old dam, saltwater intrusion is still a problem in the Charles River Basin. Lock operations for boats travelling upstream at high tide introduce the greatest amounts of saltwater into the basin. During these operations, the lock is initially filled to the harbor elevation by gravity flow with harbor water (saltwater). When a boat enters the lock, the gates close, and saltwater in the lock is emptied to the basin elevation. According to the original operation procedures, saltwater from the lock should empty to a wet well and be pumped back into the harbor. Unfortunately this procedure is not always used; mostly because it is extremely time

consuming, but also because the wetwell valves and pumps are in poor condition and are difficult and costly to maintain. Consequently, saltwater in the lock is usually emptied into the basin through the basin-side culvert gates, bypassing the wetwell operation. Not only does this increase saltwater passage to the basin, it also reduces the working life of the culvert gates. Regardless of whether the original operation procedures are used, some saltwater always enters the basin when locking upstream especially during high tide. When the lock and basin water surface elevations are the same, saltwater in the lock will flow into the basin upon opening of the basin navigation gate. This occurs because saltwater is heavier than freshwater. At high tides the situation is magnified because the lock initially contains more seawater.

At present, MDC operates the locks for boat passage and occasionally for fish migration. Lock operations for fish migration are infrequent and random depending on how many fish can be locked through during a particular operation. Fish are sometimes locked upstream after a downstream navigation operation. Freshwater in the lock is drained by the downstream culvert gates to an elevation equal to the harbor water surface elevation. Freshwater from these culvert gates attracts fish to the lock area. When the harbor lock gates open, freshwater in the lock lures fish in. If enough fish enter the lock, MDC personnel will close the harbor and open the basin lock gates allowing fish to pass upstream.

Through periods of little downstream boat traffic, the method of locking fish upstream may be enhanced by deliberately providing freshwater attraction to migrating fish. This process should be limited to lock operations during low tides to reduce saltwater intrusion into the basin. The MDC could fill the locks with freshwater from the basin using the upstream culvert gates. Once filled, freshwater from the locks would be drained by the downstream culvert gates to provide attraction water in the harbor. Once again, when water in the lock is at harbor elevation and the harbor side navigation gates open, fish would be lured in by the freshwater and locked upstream. This operation is not currently practiced at the Charles River Dam, but is being investigated as an option under this fishway rehabilitation study.

4. BASIN INFORMATION

Drainage area at the new Charles River Dam is 309 square miles. Water surface elevation on the basin side of the dam is maintained at approximately 108 feet MDCD. Mean tidal fluctuations on the harbor side range between 101.1 and 110.6 feet MDCD, with a mean spring tide range of 11.0 feet.

The nearest U.S. Geological Survey gaging station is located about 12 miles upstream from the dam on the Charles River at Waltham, Massachusetts. For water quality data collection months, May, July, and September, average monthly flows measured at this gaging station for the period of record (1931-1990) are 362, 129, and 113 cfs, respectively. Drainage area at the gaging station is 227 square miles, or about 73 percent of the total 309

square mile watershed at the dam. Based on drainage area ratios, flows near the dam are expected to be at least 24 percent larger.

The bottom configuration of the basin fluctuates greatly having many deep depressions. These deep cavities entrap saltwater and inhibit flushing action. Low areas exist both upstream and downstream from the Longfellow Bridge (see Figure 2 for bridge location); however, the streambed at the bridge itself is fairly high. This high section acts as a barrier and prevents flushing of saltwater from the upstream low areas. Bottom elevation differences downstream from Longfellow Bridge are not as severe and saltwater flushing is made easier. Low level releases from the low sluice gate at the new dam also induce flushing action. Releases made from the low sluice can also flush out hydrogen sulfides and other contaminants present in bottom waters. Although flushing of hydrogen sulfide from the basin is desirable, if toxic concentrations exist, hydrogen sulfide releases into the harbor can cause fish kills.

An artificial destratification system was installed at Charles River Basin in 1979 to provide sufficient DO throughout the basin and to reduce salinity and hydrogen sulfides in the lower water column. The destratification system was designed to maintain 4 mg/l DO throughout the basin using compressed air to be distributed by six air diffusers located throughout the basin as shown in Figure 2. According to the June 1981 Charles River Artificial Destratification Project study conducted by the MDC, the system was successful in reducing salinity and increasing DO in the bottom waters, and significantly reducing sulfides. Since first installed, operation of each diffuser has varied depending on costs and maintenance problems. This year (1991), only three diffusers are operating, numbers 1, 2, and 3, located at the upper end of the basin upstream from Longfellow Bridge.

5. WATER QUALITY CLASSIFICATION

Charles River, from the Watertown Dam downstream to the Charles River Dam, is rated class B by the Massachusetts Division of Water Pollution Control (MDWPC). According to the MDWPC, class B waters are designated an acceptable habitat for aquatic life and wildlife, and for primary and secondary contact recreation. These waters are to be suitable for public water supply following appropriate treatment, irrigation and other agricultural uses, and compatible industrial cooling and process uses.

Technical requirements for class B waters include a minimum dissolved oxygen concentration of 5 mg/l, pH in the range of 6.5 to 8.3 standard units, no fecal coliform bacteria in excess of a log mean of 200 organisms per 100 ml sample, and maximum water temperature of 28.3 degrees Celsius (83 degrees Fahrenheit). These standards further prohibit color, turbidity, solids, taste and odor that are aesthetically objectionable or would impair any use assigned to this class; and also require that the waters be free from pollutants in concentrations exceeding the most sensitive receiving water use.

Since Charles River Dam acts as a tidal barrier to the river basin, all waters downstream from the dam are considered coastal/marine. Boston Inner Harbor is located immediately downstream from the dam, and is rated class SB by the MDWPC. Technical requirements for class SB waters are similar to class B waters except the following: temperature should not exceed a maximum daily mean of 26.7 degrees Celsius (80 degrees F) and pH shall be in the range of 6.5 to 8.5 standard units.

6. HISTORICAL WATER QUALITY CONDITION

For the most part, Charles River Basin water quality usually does not meet all the conditions identified by its class B standard. Water quality data is collected periodically by MDWPC from the basin sampling stations. According to the 1984 Water Quality Survey Data report, the saltwater wedge and corresponding low DO levels are still a problem in the basin. This problem exists even though the air diffusers, when operating, increase dissolved oxygen and reduce the wedge. Although dissolved oxygen at the bottom of the water column is extremely low, DO levels in the surface waters are quite high, usually well above state standards. In addition, pH levels throughout the water column usually meet standards despite the stratification.

Saltwater present in the basin sinks to the bottom as it is more dense than freshwater, forming a stratified layer or wedge. This saltwater wedge does not mix with upper waters because of the density differences, and becomes devoid of oxygen. Contributing to this oxygen deficit are highly organic oxygen demanding sediments originating from combined sewer overflow discharges. Also, anoxic saline waters overlying organic sediment promote hydrogen sulfide production. Overall, the high salinity, low to zero DO, and presence of sulfides create an extremely toxic environment to aquatic life, restricting habitat to the upper layers of the water column. Hydrogen sulfide can cause fish kills if released to surface waters or other areas of initially good aquatic habitat. In the past, hydrogen sulfide has been released causing fish kills at the upper end of the basin where shallow waters occasionally overturn by wind and wave action. Fish kills caused by turnover have not been experienced at the lower end of the basin near the dam, since this area is fairly deep.

Other problems identified in the MDWPC report include presence of toxicants in the water and sediment and the existence of enteric pathogens. Toxicants originate from industrial waste discharges made prior to discharge restriction regulations and are now contained in the sediments occasionally releasing to the overlying water. Combined sewer overflows along the Charles introduce pathogens causing significant fecal coliform levels especially during storm events.

7. STUDY METHODS

Water quality profile data for this study were collected from the Charles River Basin on 24 September 1991 by the Corps of Engineers Environmental Laboratory. Past profile

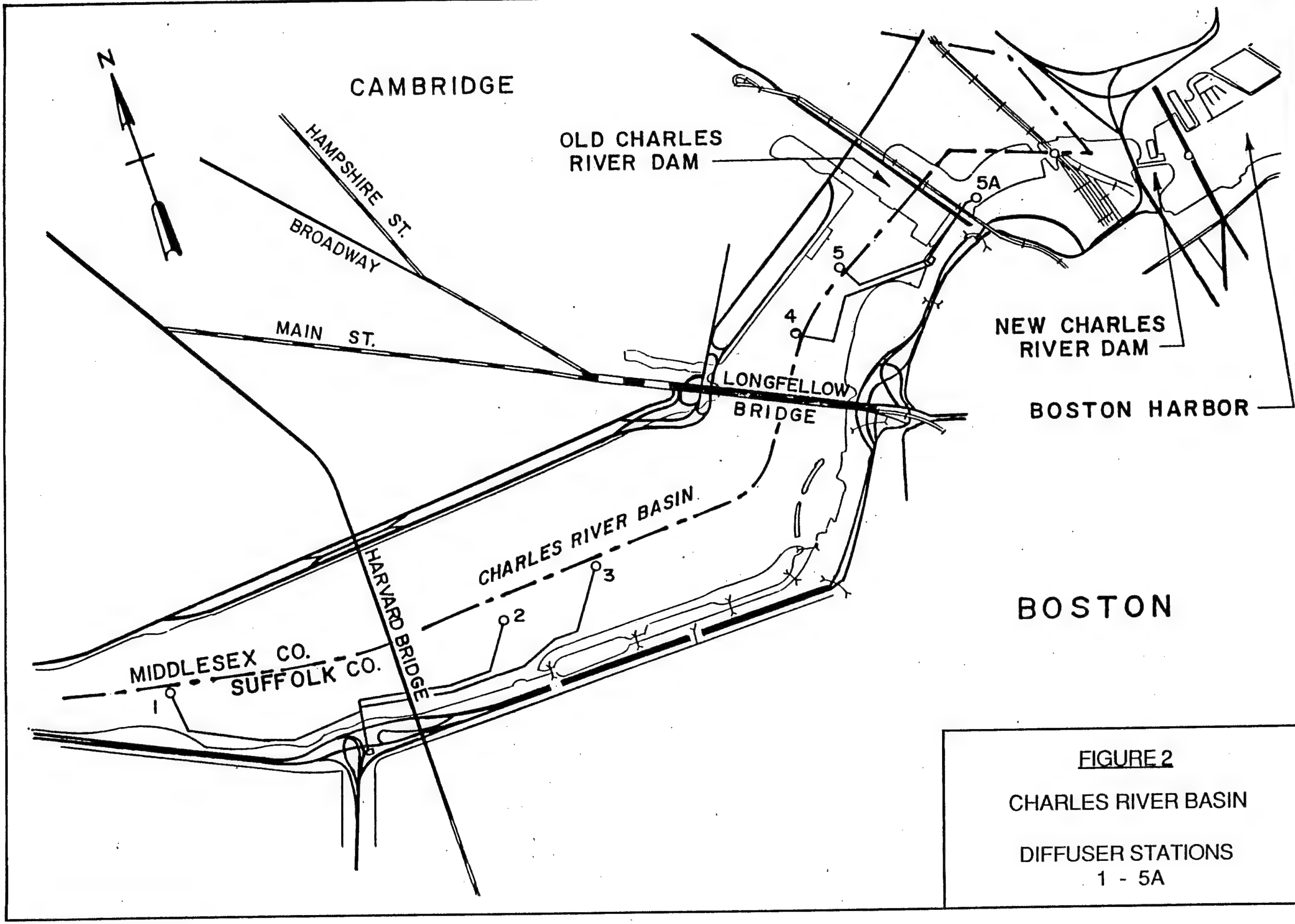


FIGURE 2

CHARLES RIVER BASIN

DIFFUSER STATIONS
1 - 5A

data includes measurements made on 23 May, 6 July and 6 September of 1989 by the Massachusetts Department of Environmental Protection (DEP). Profiles were also measured in 1976, 77, 79, and 80 for the June 1981 Charles River Artificial Destratification Project report produced by the MDC.

Profile sampling stations for 1991 data are shown in Figures 1 and 3. Dissolved oxygen, temperature, salinity, pH and conductivity were measured at each station. These parameters were sampled 2 feet below the surface and at 2-foot intervals to the basin invert. In addition to profiling data, grab samples were obtained 1.5 feet from the bottom and were analyzed for hydrogen sulfide.

Of the sampling stations shown in Figure 3, stations 1A, 1, and 2 had been used by the DEP for 1989 data. Additional DEP stations are located further upstream, but do not significantly influence this fish passage improvement study. Parameters measured in 1989 included dissolved oxygen, temperature, salinity, and percent oxygen saturation. These parameters were sampled about one-half meter below the surface, at 2 meters below, and then at intervals of two meters to the basin invert. Grab samples were also taken one half meter from the bottom of the basin and were analyzed for hydrogen sulfide, as well as, total and fecal coliforms. These data were collected by the DEP when the destratification system was not operating; however, in the fall of 1989 (after the September sampling) the system was repaired and continues to operate today.

Water quality profiles were measured by the MDC in 1976 and 1977 prior to activation of the destratification system, while 1979 and 1980 profiles were measured during system operation. Those stations located downstream from Harvard Bridge are shown in Figure 4, and samples were taken from the surface and at intervals of 5 feet to the bottom of the basin. At each station, all of the above parameters were measured with the exception of percent dissolved oxygen saturation.

8. STRATIFICATION PATTERNS

September 1991 data collected by the Corps near the dam at stations 1A through 1D show the hypolimnium begins to form at elevation 90.0 feet MDCD with water quality conditions deemed harmful to aquatic life below elevation 88.0 feet MDCD. A saltwater wedge below this elevation exists with salinity levels exceeding 5 parts per thousand (ppth) and increasing with depth to as high as 15.5 ppth at station 1B. According to the Addendum to Charles River Fisheries Report, a salinity level below 5 ppth should be maintained to protect sensitive freshwater fishes in the Charles River Basin. Within the saltwater wedge, dissolved oxygen is less than 5 parts per million (ppm) decreasing to a low of 1.65 ppm near the bottom sediments. State standards recommend DO above 5 mg/l to protect sensitive resident aquatic organisms. Temperatures decrease with depth as well, although not as severely, and pH decreases with depth even less.

Figures 5, 6, and 7 identify the September 1991 hypolimnion near the dam in relation to the fishway, flood control sluice gates and the large lock and small lock 1 culvert gates, respectively. Water entering the fishway and flood control high sluice from the basin side is of fairly good quality since the fishway sluice gate (sill elev. 105 feet MDCD) and wetwell (bottom elev. 100 feet MDCD) and the flood control high sluice (sill elev. 97.5 feet MDCD) draw water from well above the September 1991 hypolimnium. However, with an invert elevation at 87 feet MDCD, the low sluice gate releases water from the hypolimnion inducing flushing action which helps decrease the saltwater wedge. Invert elevations of the culvert gates indicate the large culvert intakes draw water from the upper part of the saltwater wedge, while the small culvert intakes of lock 1 draw freshwater from above the wedge. Since only this small lock's culvert intakes draw freshwater (the north side culverts of small lock 2 connect to the large lock's south culvert intakes), this lock would be the best to use to facilitate locking of migrating fish.

Since the low level flood control sluice gate and the large lock culvert intakes draw water from the hypolimnium, some of the highly saline, low DO water is flushed from the basin during each gate operation. These flushing effects decrease further upstream, as evident in comparing the September 1991 Corps data of station 1A near the dam to stations 1 and 2 located further upstream (see Figures 8, 9, and 10 showing dissolved oxygen profiles of 1989 and 1991). Although the wedge begins at about the same depth, 1991 data collected at stations 1 and 2 indicate more severe conditions than in 1989. Conditions near the bottom are close to anoxic with higher salinity concentrations, up to 22.8 and 18.9 ppth at stations 1 and 2 (Figures 12 and 13), respectively.

Data collected in 1989 by the DEP show a thicker saltwater wedge with higher salinity levels and lower DO levels in the upper water column than those measured in 1991 by the Corps. DO levels for 1989 do not drop as sharply near the bottom as in 1991. At station 1A, closest to the dam, the 1989 wedge begins 1.5 feet above 1991 data at an elevation of about 91.5 feet MDCD. At this elevation, the large lock culvert intakes would draw in even more saltwater. However, culvert intakes at small lock 1 (invert elevation 93.25 feet MDCD) would still draw freshwater from above the wedge. Maximum salinity concentrations at station 1A in 1989 reached 23.5, 15.8, and 23.3 ppth near the bottom in May, July, and September, respectively. Corresponding minimum DO concentrations are 4.5, 2.4, and 3.1 ppm. Once again, these 1989 parameters generally become worse at upstream stations 1 and 2. DO levels near the bottom are close to zero at both stations, and salinity levels reached a maximum of 24.7 ppth in September at station 1 and 21.6 ppth in May at station 2.

Figures 8 through 16 show dissolved oxygen, salinity, and temperature profiles of 1989 (DEP) and 1991 Corps data at stations 1A, 1, and 2. Improvements in 1991 data from 1989 may be associated with operation of the destratification system. This system broke down prior to 1989 data collection and did not resume operation until late fall of that year. Operation has been continuous since 1989, reducing salinity levels. The saltwater wedge in

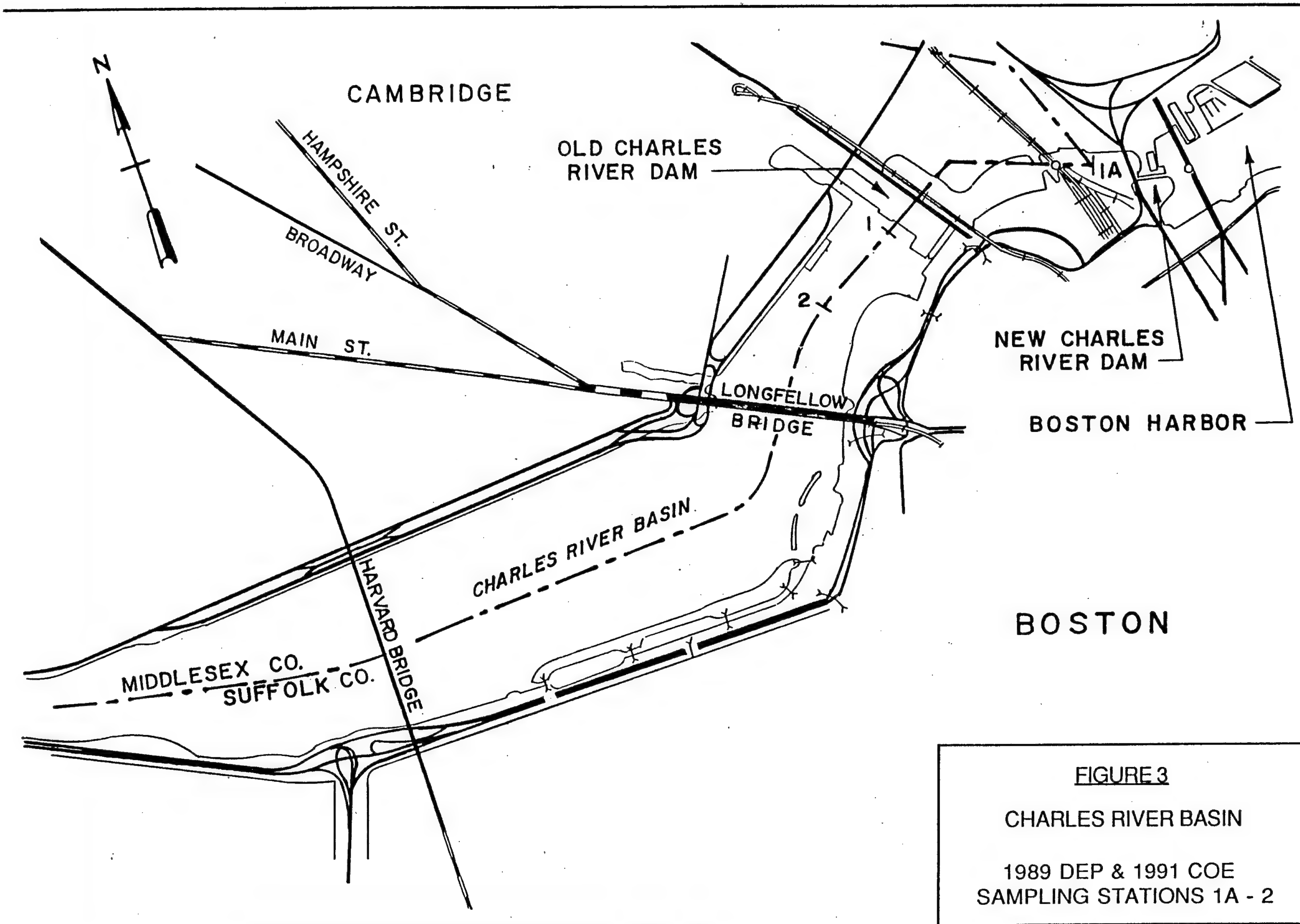


FIGURE 3

CHARLES RIVER BASIN

1989 DEP & 1991 COE
SAMPLING STATIONS 1A - 2

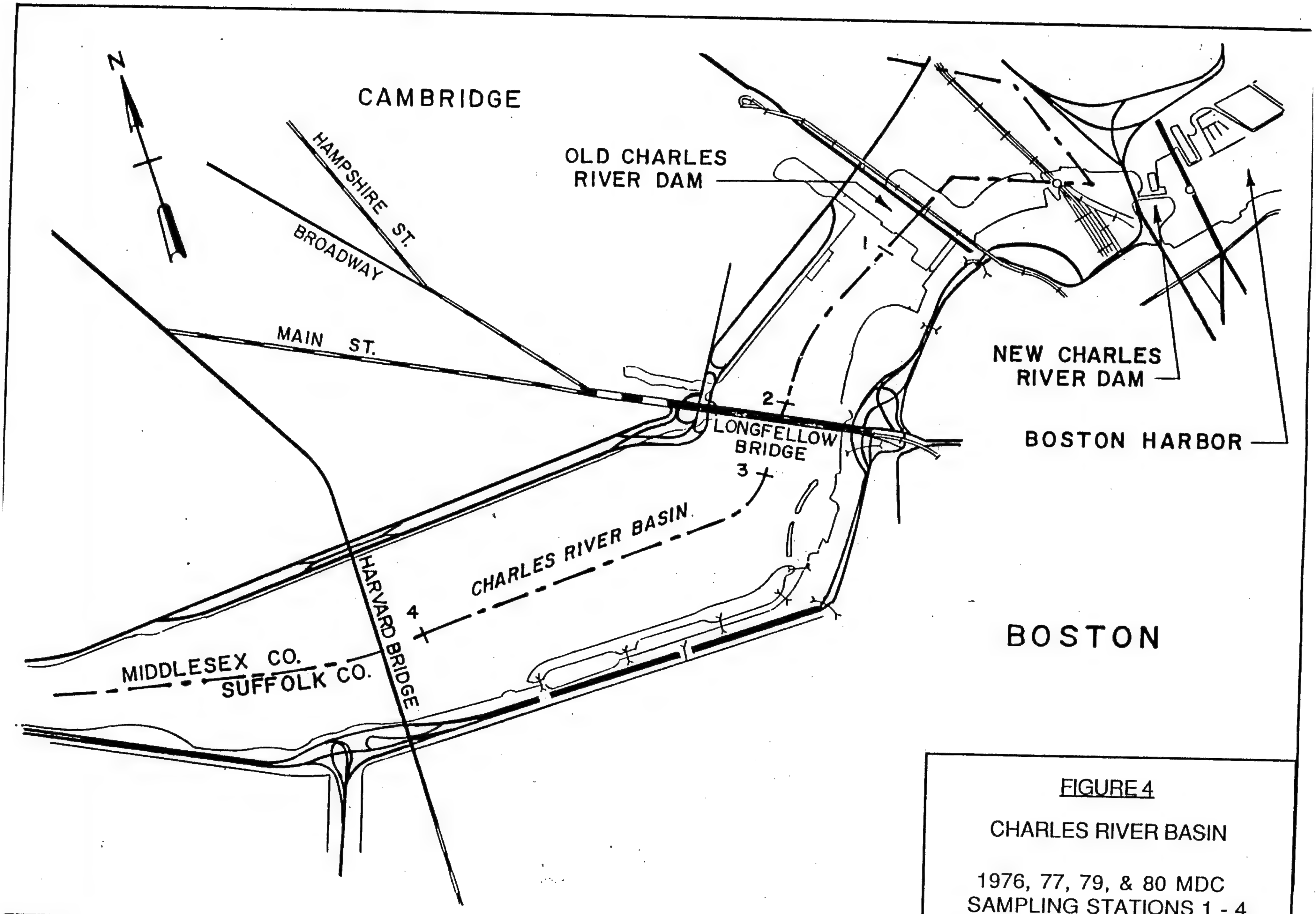
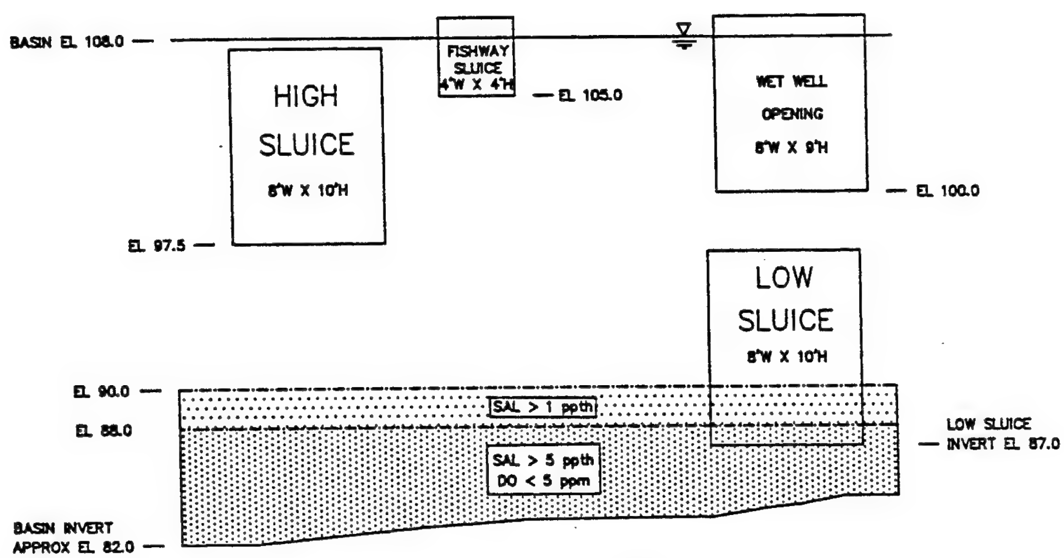


FIGURE 4

CHARLES RIVER BASIN

1976, 77, 79, & 80 MDC
SAMPLING STATIONS 1 - 4

CHARLES RIVER DAM
BASIN SIDE ELEVATIONS
FISHWAY & FLOOD CONTROL SLUICE GATES



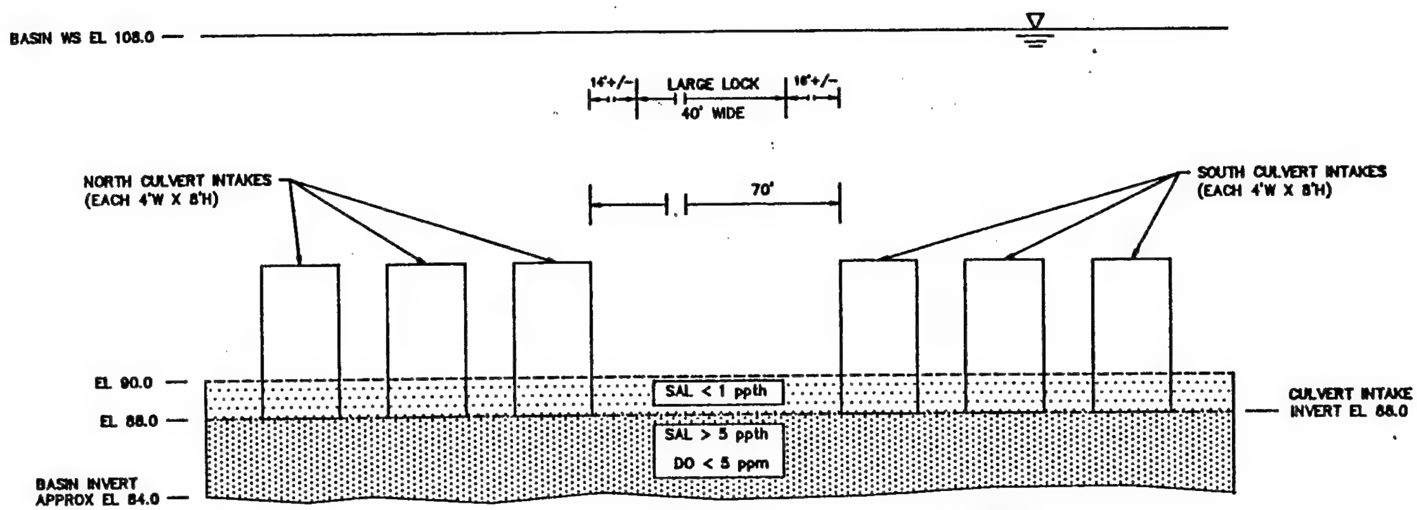
NOTES:
1. SAL and DO levels are based on Sept 1991 COE data.
2. Elevations are in feet, MDC datum

SCALE: 1" = 10'

FIGURE 5

BASIN SIDE ELEVATIONS

LARGE LOCK CULVERTS

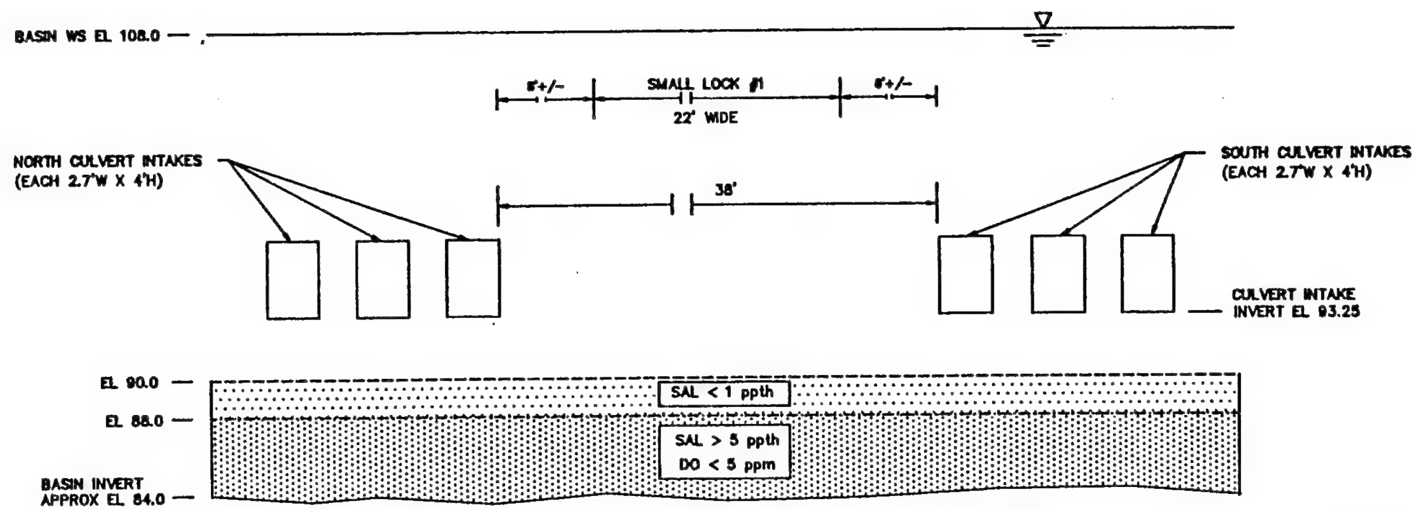


SCALE: 1' = 10'

NOTES:
1. SAL and DO levels are based on Sept 1991 COE data
2. Elevations are in feet, MDC datum

FIGURE 6

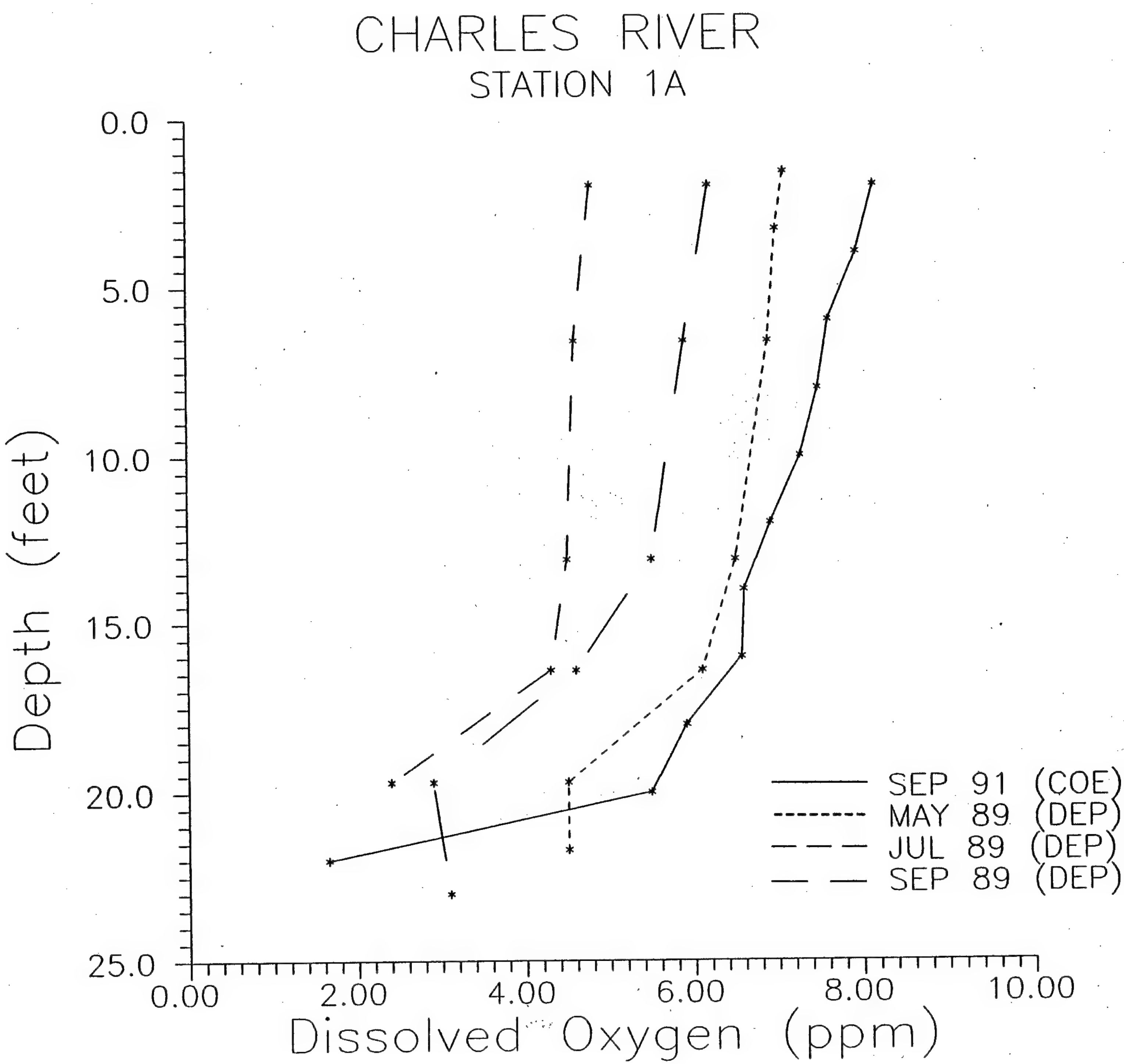
CHARLES RIVER DAM
BASIN SIDE ELEVATIONS
SMALL LOCK #1 CULVERTS



SCALE: 1" = 10'

NOTES:
1. SAL and DO levels are based on Sept 1991 COE data
2. Elevations are in feet, MDC datum

FIGURE 7



CHARLES RIVER
STATION 1A
Depth (feet)
0.0
5.0
10.0
15.0
20.0
25.0
0.00
2.00
4.00
6.00
8.00
10.00
Dissolved Oxygen (ppm)
SEP 91 (COE)
MAY 89 (DEP)
JUL 89 (DEP)
SEP 89 (DEP)

FIGURE 8

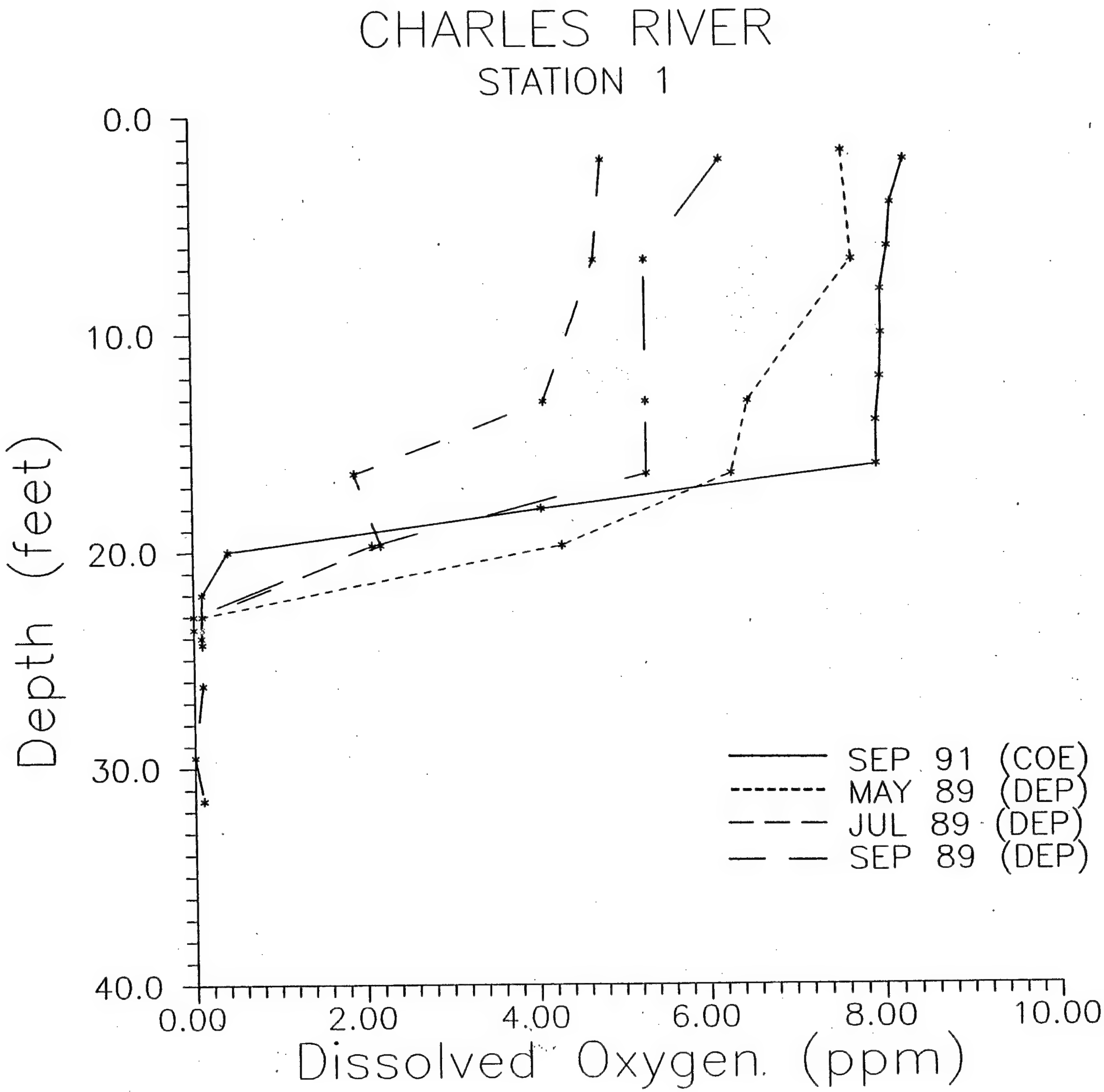
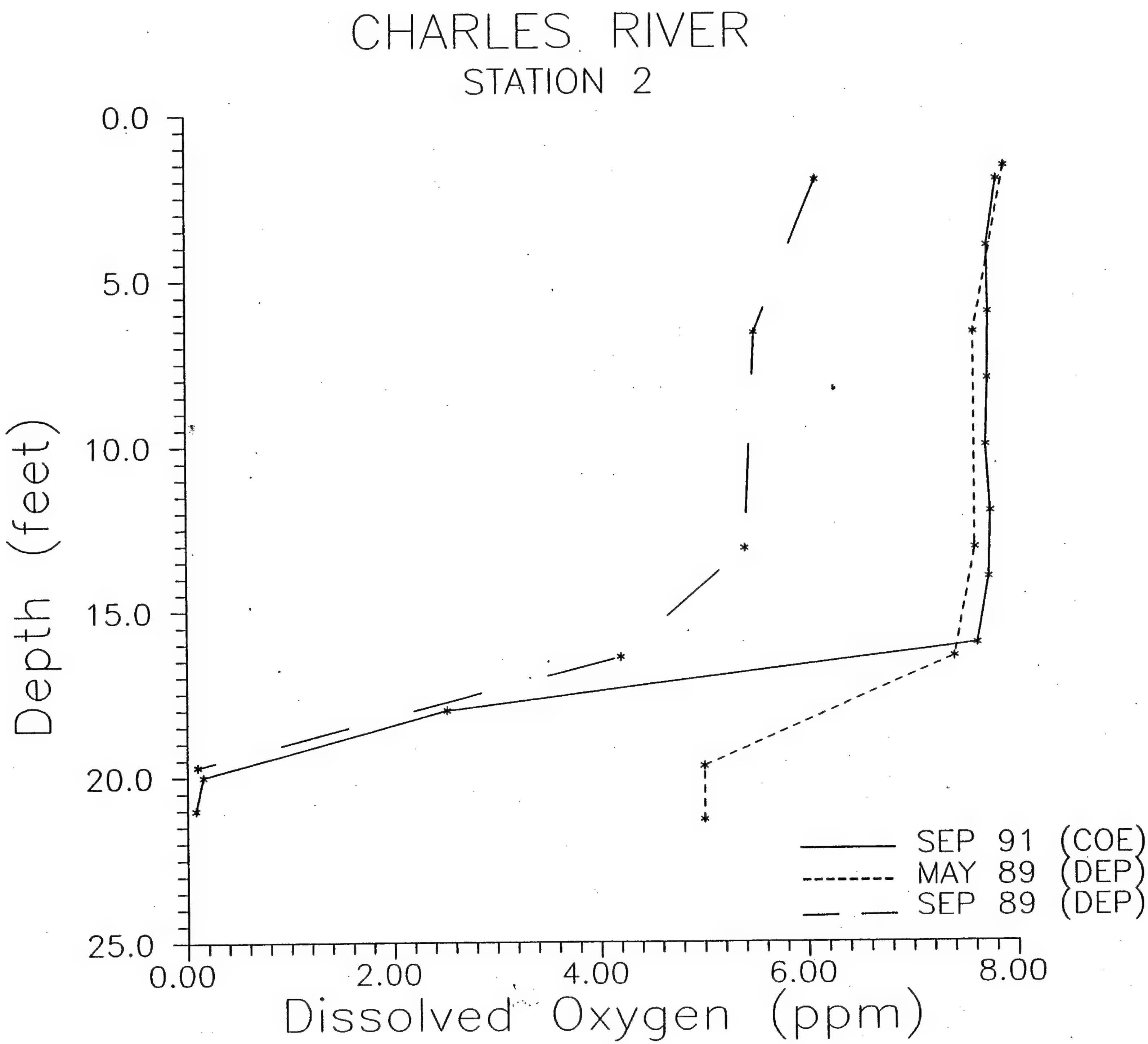
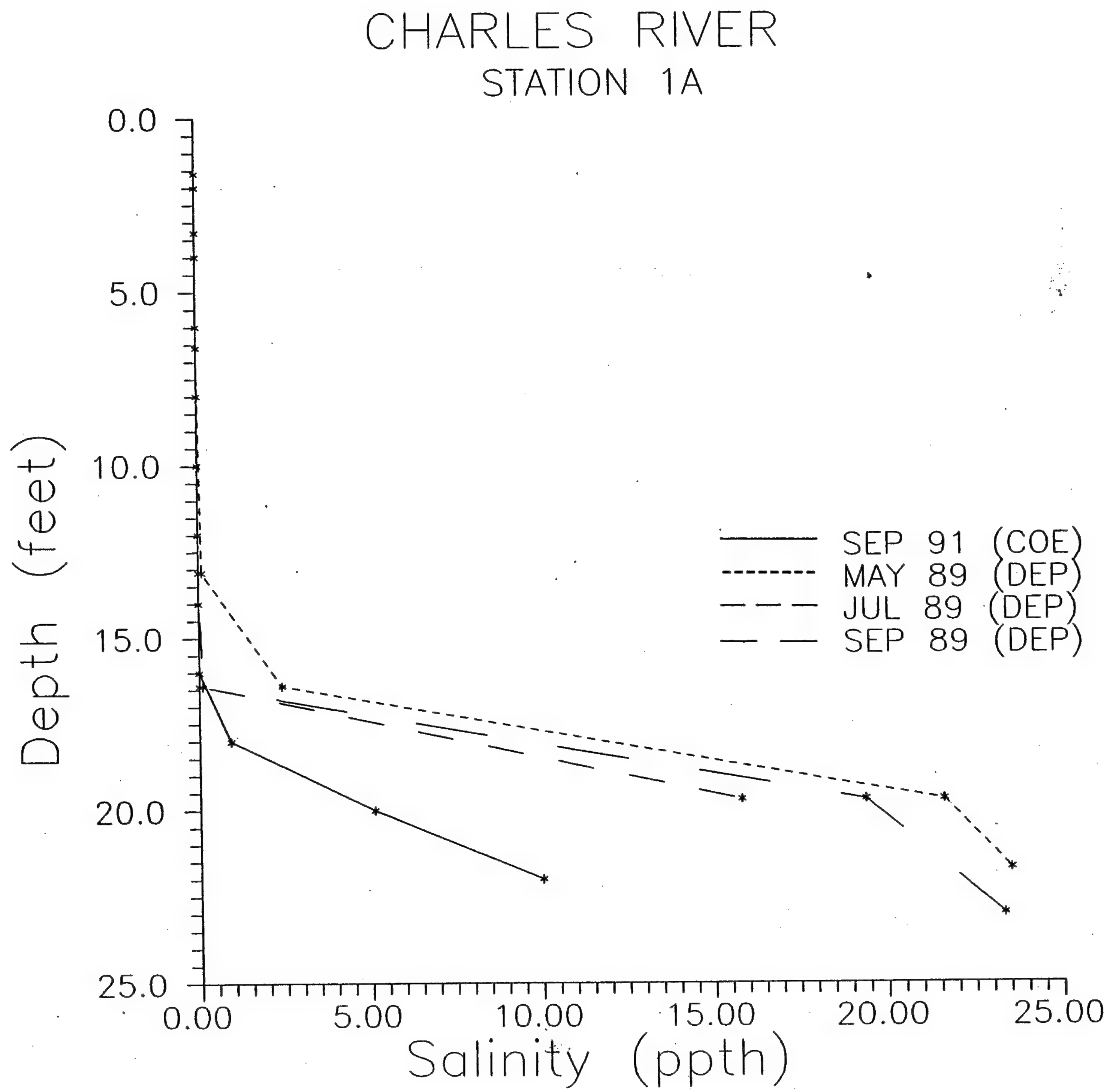

CHARLES RIVER
STATION 1
Depth (feet)
0.0
10.0
20.0
30.0
40.0
0.00
2.00
4.00
6.00
8.00
10.00
Dissolved Oxygen (ppm)
SEP 91 (COE)
MAY 89 (DEP)
JUL 89 (DEP)
SEP 89 (DEP)

FIGURE 9



CHARLES RIVER
STATION 2
0.0
5.0
10.0
15.0
20.0
25.0
Depth (feet)
0.00
2.00
4.00
6.00
8.00
Dissolved Oxygen (ppm)
SEP 91 (COE)
MAY 89 (DEP)
SEP 89 (DEP)

FIGURE 10



CHARLES RIVER
STATION 1A
Depth (feet)
0.0
5.0
10.0
15.0
20.0
25.0
SEP 91 (COE)
MAY 89 (DEP)
JUL 89 (DEP)
SEP 89 (DEP)
0.00
5.00
10.00
15.00
20.00
25.00
Salinity (ppth)

FIGURE 11

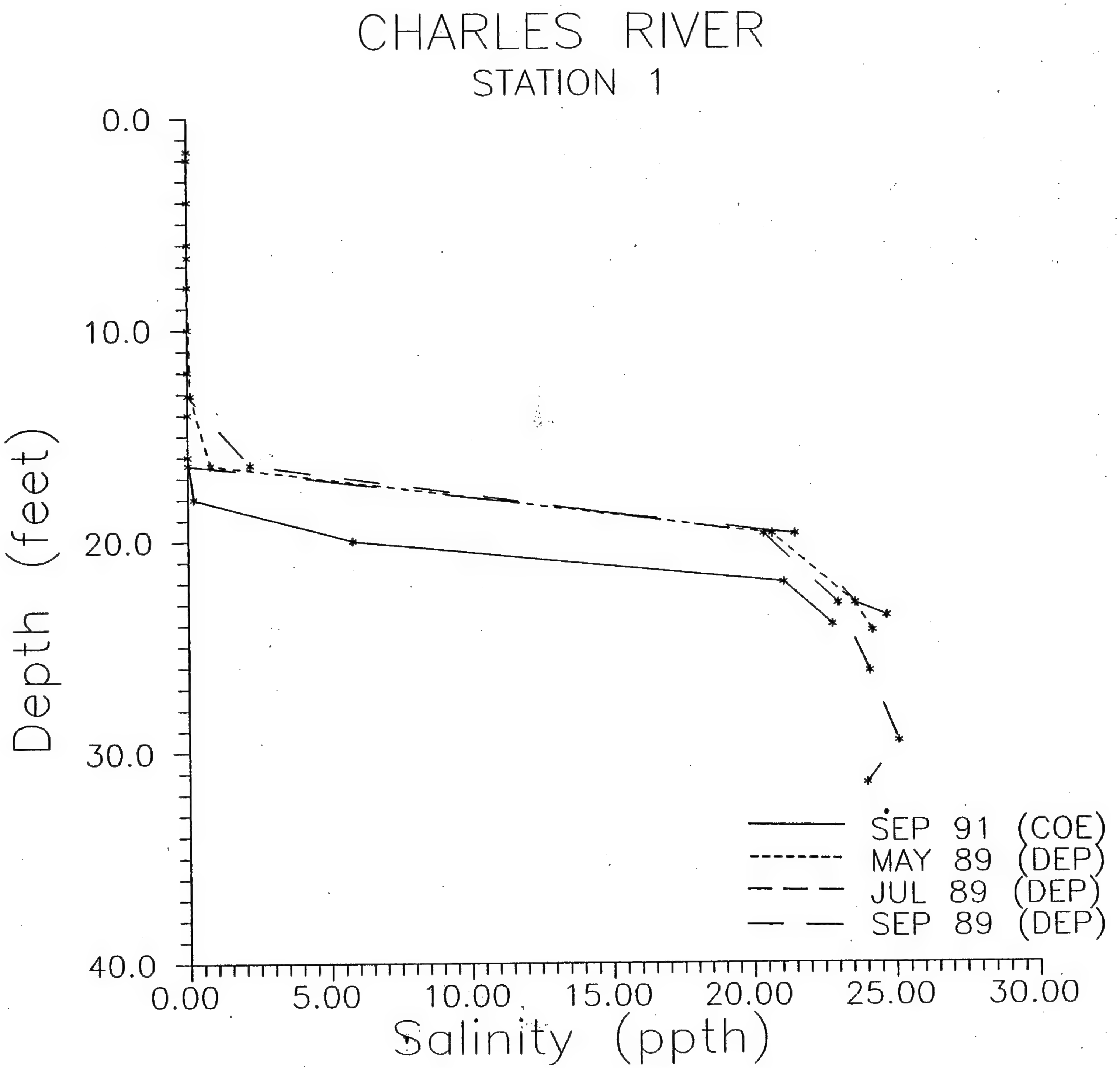

CHARLES RIVER
STATION 1
0.0
10.0
20.0
30.0
40.0
Depth (feet)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
Salinity (ppth)
SEP 91 (COE)
MAY 89 (DEP)
JUL 89 (DEP)
SEP 89 (DEP)

FIGURE 12

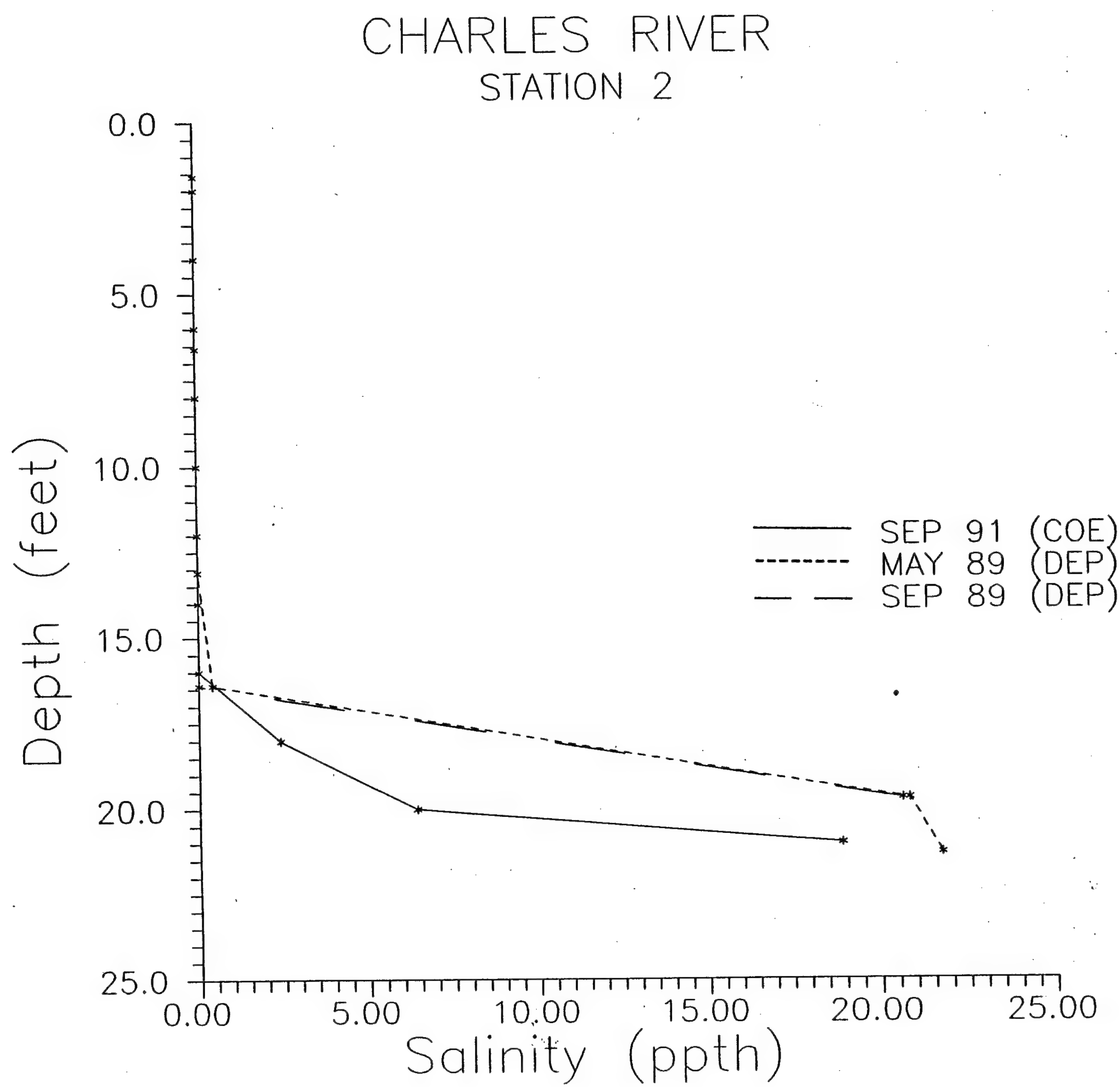

CHARLES RIVER
STATION 2
Depth (feet)
0.0
5.0
10.0
15.0
20.0
25.0
0.00
5.00
10.00
15.00
20.00
25.00
Salinity (ppth)
SEP 91 (COE)
MAY 89 (DEP)
SEP 89 (DEP)

FIGURE 13

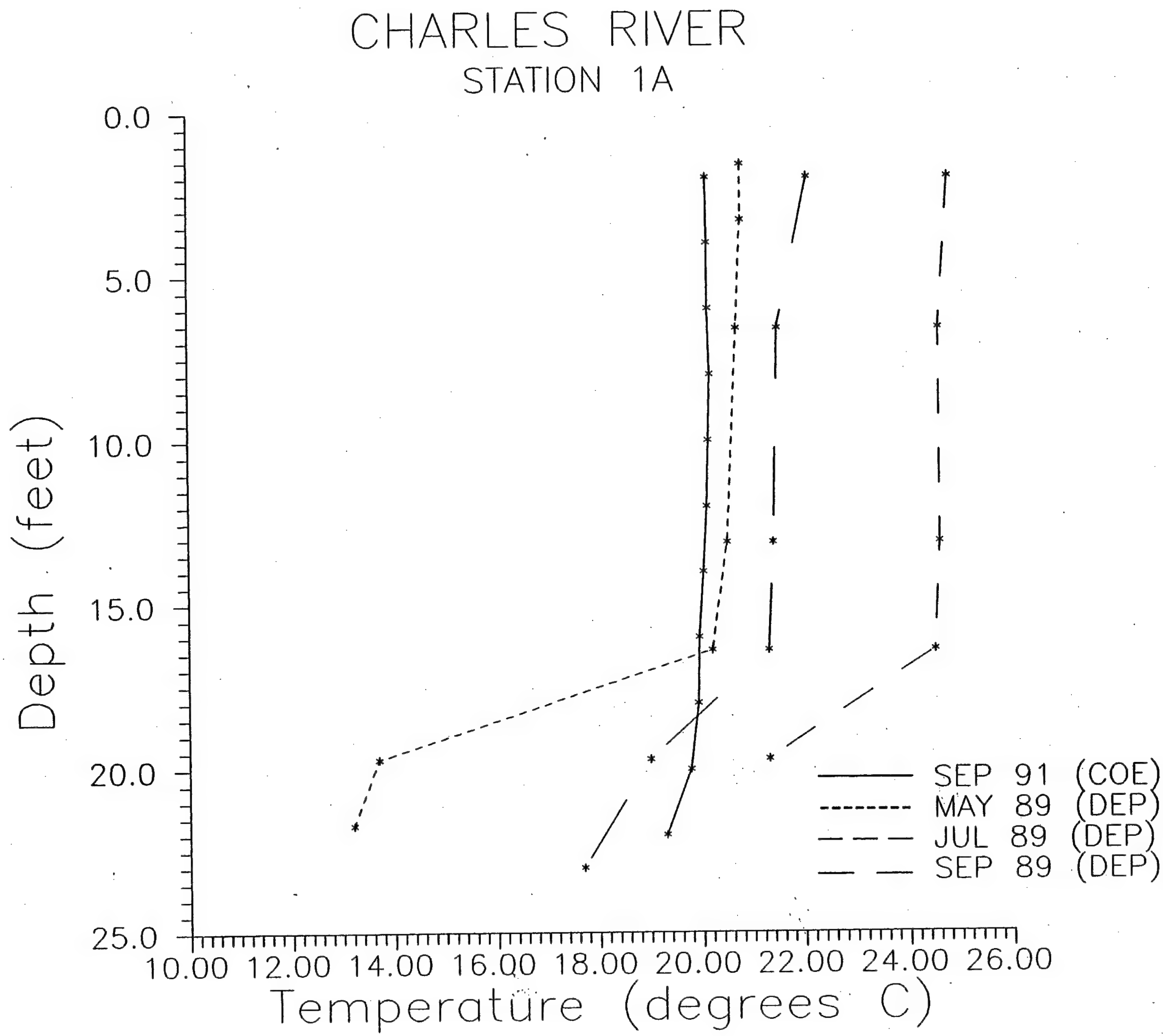
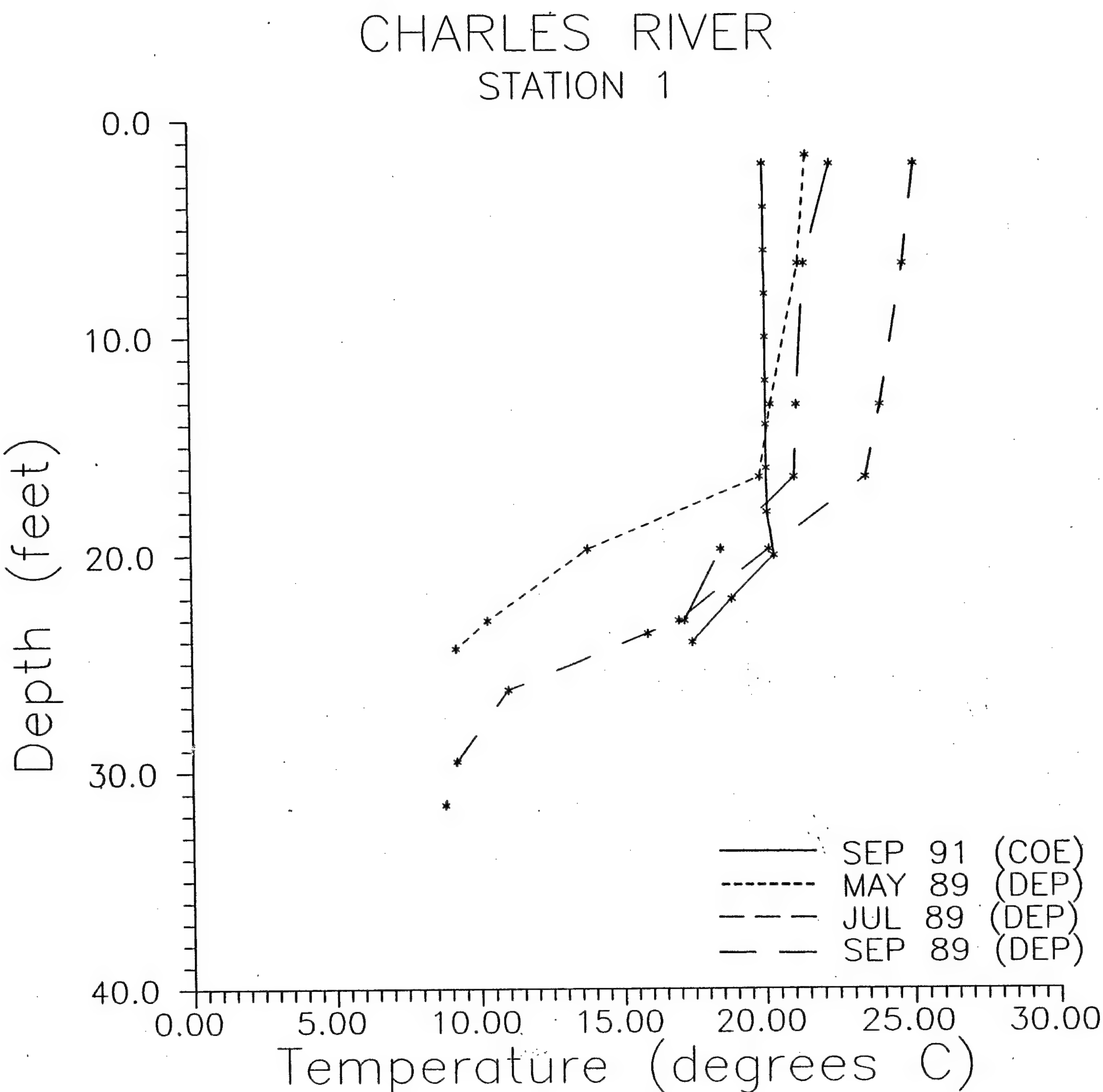

CHARLES RIVER
STATION 1A
Depth (feet)
0.0
5.0
10.0
15.0
20.0
25.0
10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00 26.00
Temperature (degrees C)
SEP 91 (COE)
MAY 89 (DEP)
JUL 89 (DEP)
SEP 89 (DEP)

FIGURE 14



CHARLES RIVER
STATION 1
0.0
10.0
20.0
30.0
40.0
Depth (feet)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
Temperature (degrees C)
SEP 91 (COE)
MAY 89 (DEP)
JUL 89 (DEP)
SEP 89 (DEP)

FIGURE 15

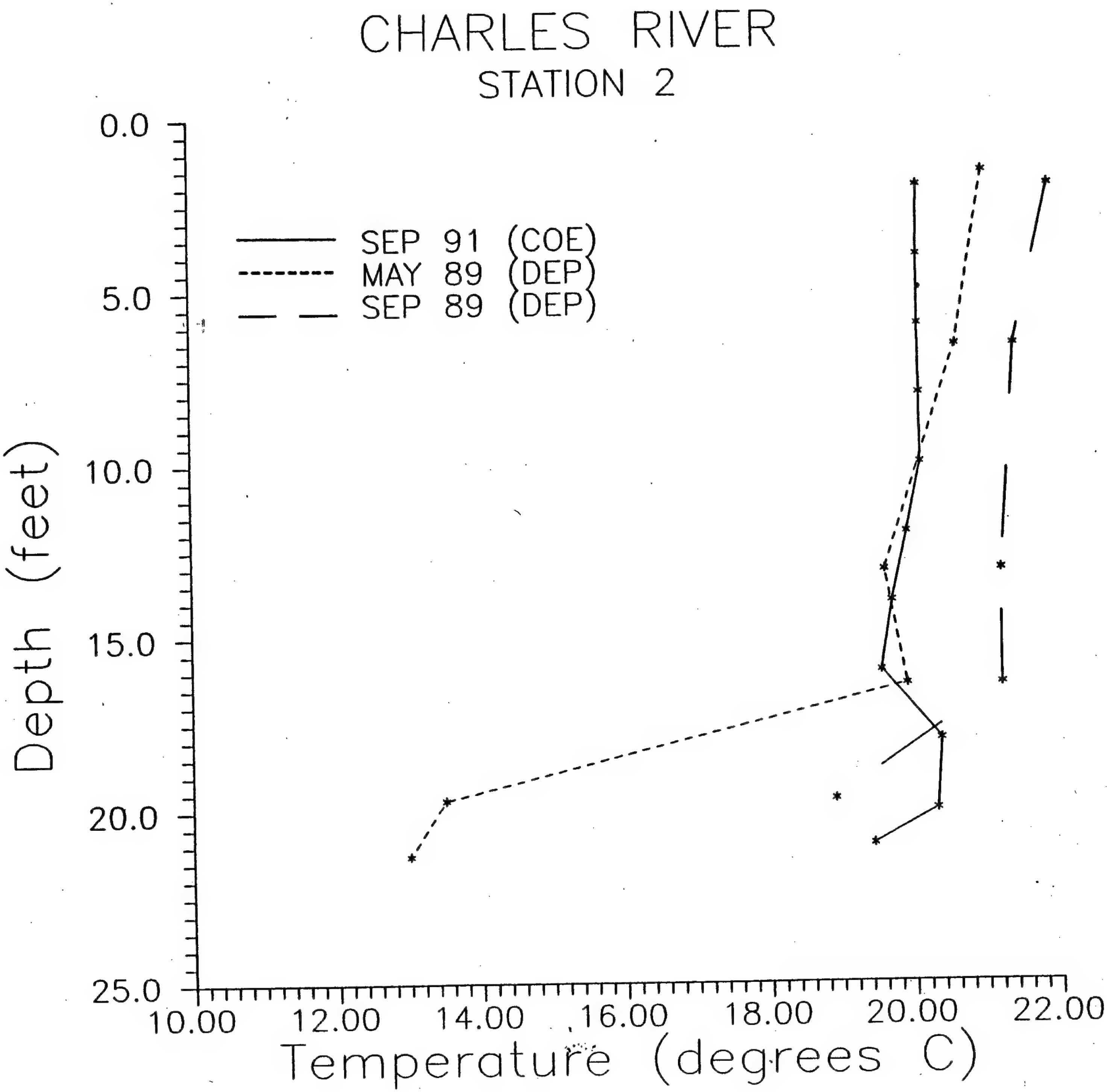

CHARLES RIVER
STATION 2
SEP 91 (COE)
MAY 89 (DEP)
SEP 89 (DEP)
0.0
5.0
10.0
15.0
20.0
25.0
Depth (feet)
10.00
12.00
14.00
16.00
18.00
20.00
22.00
Temperature (degrees C)

FIGURE 16

1991 is still fairly significant, possibly because only the three most upstream diffusers have been in operation.

Seasonal trends in DO are apparent based on 1989 data. Highest DO levels occur in May followed by September, and then July. This corresponds to 1989 average monthly inflows to the basin, where runoff at the Waltham USGS gage was greatest in May (455 cfs), less in September (220 cfs), and least in July (210 cfs). Average monthly 1989 flows for July and September are similar, in fact average monthly flows for the period of record (1931-1990) are slightly higher in July than September. The June 1981 MDC report states 1976 through 1980 DO measurements are significantly higher in the spring than in the summer and early fall. Not only does increased runoff provide more DO, but it also decreases residence times by causing waters to pass more quickly through the basin further increasing DO. In addition, increased runoff causes more turbulence at the freshwater/saltwater boundary. Consequently, the above seasonal trends in DO appear to be reasonable.

Trends in salinity are not as apparent. 1989 salinity levels are very similar during all three seasons. In addition, the further upstream the station, the less seasonal variation in salinity measurements. However, 1989 salinity levels appear to be least during July. This may have occurred because lockages are greatest in the summer; if more downstream lockages were made using the large lock, more saltwater would flush out of the basin due to increased use of the large lock culvert gates. Seasonal trends in 1976 through 1980 data contradict 1989 salinity trends. According to the June 1981 report, salinity levels from 1976, '77, '79, and '80 data are significantly higher during summer and early fall than during spring. In this case it appears more upstream lockages during the summer introduce more salinity into the basin and low summer flows inhibit flushing action. With the discrepancy in seasonal trends of salinity data, it is impossible to be sure such trends exist.

Seasonal trends can be used to estimate conditions in the spring of 1991 when no data was collected and the destratification system was operating. Preliminary estimates of mean monthly 1991 flows for May, July, and September are 313, 65.3, and 188 cfs, respectively. If DO increases with flows as seasonal trends suggest, then spring DO levels are expected to be much higher than the September 1991 data, assuming destratification system operation. Higher DO levels may reduce sulfides in the bottom waters, as hydrogen sulfide quickly converts back to sulfate in aerobic waters.

Nevertheless, since salinity levels seem to remain about the same the saltwater wedge thickness would also remain about the same. As a result, the large lock culvert gates would still draw water from the saltwater wedge.

9. HYDROGEN SULFIDE CONDITIONS

Presence of hydrogen sulfide gives an indication of the waters potential to corrode certain construction materials and aquatic toxicity. Hydrogen sulfide levels measured in 1991 in the bottom waters near the dam at stations 1B, 1C, and 1D are less than 1 mg/l. This seems reasonable because the bottom waters near the dam are somewhat aerobic.

Hydrogen sulfide was detected in the 1989 DEP samples, as shown in the following table:

HYDROGEN SULFIDE IN MG/L

Station	23 May 89	6 July 89	6 Sept 89
1A	<0.1	<0.2	0.4
1	2.0	>26.0	4.0/4.0*
2	1.6	--	0.2

* Split field sample (two samples collected/analyzed from one sample aliquot).

The closest station to the dam, 1A, shows that hydrogen sulfide levels are fairly low. Low levels even occurred in July at this station when corresponding dissolved oxygen levels were close to zero. Based on 1989 and 1991 hydrogen sulfide data measured in the vicinity of the dam, hydrogen sulfide conditions do not appear to be highly toxic. However, the potential for hydrogen sulfide to reach corrosive levels near the dam is fairly high, since only four H_2S measurements were made and because high hydrogen sulfide levels were measured at station 1.

In the Addendum to Charles River Fisheries Report, a critical level of 2.5 mg/l hydrogen sulfide was established for the Charles River Basin to protect sensitive fish species. Violation of this criteria occurred at station 1 in July and September of 1989 as shown in the above table. Since sulfides are restricted to the highly saline low DO waters located a7ong the bottom, fish are likely to stay out of this area. Also, since levels at stations near the dam are fairly low, waters from the saltwater wedge being sluiced through the low level flood control gate and large lock culvert gates will most likely be free from toxic sulfide concentrations.

10. CONCLUSION

A well defined hypolimnium, composed of a saltwater wedge with low to anaerobic dissolved oxygen levels and low to high hydrogen sulfide concentrations, is present in the Charles River Basin. This wedge usually thickens when the basin's destratification system is not in operation. The low sluice flood gate, large lock culvert gates, and small lock 2 north side culvert draw water from the top of the hypolimnium which flushes some of the saltwater from the basin. Consequently, the wedge is not as thick near the dam as it is in upstream portions of the basin.

Water is drawn into the fishway and high flood control sluiceway from well above the saltwater wedge on the basin side. Therefore, this water is generally of good quality with dissolved oxygen levels above the recommended State standards and zero salinity. Water in the vicinity of the locks is also of interest to this fish passage improvement study, as fish migration through the locks can be enhanced by deliberately passing water from the basin to the harbor. Small lock 1 draws water of acceptable quality for aquatic habitat and, therefore, could be used for this enhancement process. However, although fish are currently locked through all three locks on occasion or during navigation operations, use of small lock 2 and the large lock for the enhancement process is not advisable due to poor water quality.

Water in the vicinity of the small culvert intakes (lock 1 and south side of lock 2) are above the saltwater wedge and are of acceptable quality for aquatic habitat. Since these culverts are used to fill the locks with basin water, water released into the locks would be of fairly good quality. On the other hand, culvert intakes for the large lock and small lock 2 (north side culvert only) have inverts at the top of the hypolimnium, releasing poor quality water into the locks. When fully open, the large lock culvert intake inverts draw highly saline waters with low DO content from the wedge which may be toxic to fish as well as cleaner aerated water from above the hypolimnium. When these waters are released to the locks, they may become fairly well mixed and aerated through turbulence encountered in the intake structures and culverts. Therefore, these locks may pass waters of acceptable quality for sensitive fish species provided the wedge is relatively small and sulfide levels are low. However, acceptable water quality in the locks cannot be guaranteed as water quality conditions near the culvert intakes are usually unknown at the time of operation. Therefore, use of small lock 1 is recommended to enhance fish passage through the locks with the highest quality water possible.

Enhancement of fish passage through increased lock operations should not significantly increase saltwater intrusion into the basin. Additional upstream lock operations for fish passage should be limited to low tide periods to reduce saltwater intrusion. Since enhancement operations would be infrequent as most fish would be locked through during regular boat lockages, relatively little saltwater would be passed into the basin.

Hydrogen sulfide is present near the dam in relatively small concentrations. Based on 1989 and 1991 data, the maximum hydrogen sulfide concentration in the vicinity of the dam is 0.4 mg/l. Hydrogen sulfide concentrations increased to more significant levels at stations sampled upstream from the dam. The basin maximum hydrogen sulfide concentration from 1989 and 1991 data is greater than 26 mg/l measured at station 1.

11. REFERENCES

a. Metropolitan District Commission, Charles River Artificial Destratification Project, Boston, Massachusetts, June 1981.

b. U.S. Army Corps of Engineers, New England Division, Charles River Dam Design Memorandum No. 2, Waltham, MA, February 1972.

c. U.S. Army Corps of Engineers, New England Division, Charles River Dam Operation and Maintenance Manual, Waltham, MA, July 1979.

d. U.S. Department of the Interior, Massachusetts Division of Fish & Wildlife, "Addendum to Charles River Fisheries Report."

APPENDIX D

INSPECTION REPORT FISH PASSAGE FACILITY

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LIST OF FIGURES

CHARLES RIVER DAM
FISH PASSAGE FACILITY
INSPECTION REPORT

1. FIELD INSPECTION

In support of the feasibility study concerning restoration of the subject fish passage facility, members of General Engineering Branch inspected the facility during the fall of 1991. Inspections were performed by Mr. Anthony Mackos and Ms. Deborah Gabrielson (mechanical), Mr. Joseph Colucci (structural), and Mr. Frank Turner (electrical) on 8 October, 4 November, 4 December and 9 December. Mr. David Sward of Basin Management Division was present during all these inspections. In addition, he witnessed inspection related activities during times when representatives of GEB could not be present, and provided information to GEB for inclusion in this report. The inspection was hampered by several unsuccessful attempts to dewater the fishway. Contractor fabricated stop logs at both ends of the fish passage failed on three occasions. However, partial dewatering finally did take place on 4 December. The pump wet well could not be dewatered due to failure of the Contractor fabricated stop log which had been inserted in pump wet well screen slots. Instead, pipe plugs were inserted into the gravity feed lines so as to allow dewatering of the constant head tank, valve pit and fishway.

2. OBSERVATIONS AND EVALUATIONS

a. FISHWAY PUMP AND MOTOR

(1) The pump and motor were removed several years ago by the MDC. Both are inoperative. The motor is stored in the pumping station and the pump is lying on the concrete deck out in front of the station. Mr. Larry Richards of Fluidtek Associates, a Patterson Pump representative, was also present at the inspection which took place on 4 November 1991.

(2) The pump outer casing, discharge head and shaft enclosing tube (all made of fabricated steel) are moderately corroded. (See Figure 1.) The motor base plate (also fabricated steel) is in good condition.

(3) The stainless steel shaft and bronze impeller appear to be in very good condition. (See Figure 2.)

(4) The cast iron diffuser is severely corroded. (See Figure 3.) The cast iron suction bell and lower bearing support are only moderately corroded, but there are numerous hairline cracks in the bearing support which is an integral casting with the suction bell. (See Figure 4.)

(5) The motor is burned out. According to the Boston Motor Rebuilding Company where it was last sent for assessment, the motor is beyond economic repair.

b. FISHWAY SLUICE GATE

The fishway sluice gate was inspected by Daylor Consulting Group on 30 September 1991. According to their report, the gate is in good to excellent condition.

c. AUTOMATIC GATE AND PUMP CONTROLS

The fishway sluice gate and pump are designed to be automatically controlled in response to changing water levels. Level sensors are missing or not functional. The sluice gate is not presently connected to the level sensors. It can be operated manually. As stated above, the pump and motor have been removed and are no longer connected to the control system.

d. PUMP WETWELL SCREEN AND TRASH RACK

The 1/4" mesh stainless steel screen was missing and could not be located. Screen guides are present and in good condition. The trash rack appeared to be in good condition.

e. GRAVITY FLOW LINES AND FLAP VALVES

The two gravity flow lines leading from the pump wetwell to the constant head tank were jet cleaned and examined by video camera on 4 December. The lines were clear and in good condition. Flap valves showed moderate corrosion, but appeared to be functioning adequately.

f. DIFFUSER LINES AND BUTTERFLY VALVES

(1) Contractors were unable to dewater the fishway on 7 October, due to leakage around the fabricated stop log at the harbor end. On 8 October, the butterfly valves in the three diffuser lines were closed and the constant head tank was partially pumped down. Each of the three valves was then opened and closed in turn. Water was observed to flow back into the constant head tank from the harbor end of the fishway through two of the lines. The middle line (feeding pool number 4) showed no flow, indicating that that line was completely blocked. As a result of this test and due to later difficulties in dewatering the fishway, it was decided to jet clean all three lines, examine as much of the interior portion of the lines as possible with a remote video camera, and to pull only the middle butterfly valve for inspection. The assumption was made that the condition of the other two valves would be similar to that of the middle valve.

(2) During the portion of the inspection which took place on 3 and 4 December when most of the fishway was successfully dewatered, the three lines were jet cleaned, portions were videoed, and the 20" butterfly valve was removed from the middle diffuser

line. The video camera was not able to negotiate any significant pipe bends, so only the first 30 feet (from the morning glory weirs) of the lines feeding pools 2 and 6 were videoed. These lines were clear, except for a piece of 2x4 in the 20" line. The 20" line showed a lot of barnacle growth on its interior surface. The 24" line, in contrast, was practically clean.

(3) The vertical diffuser racks were removed from pool 4. The racks were in good condition although partially obstructed by plant and animal growth. It was found that the diffuser grating had been removed from the end of the pipe. The end of the diffuser pipe was clogged with debris including a plastic trash bag. One of the contractor's divers cleared the debris out by hand and visually inspected the end of the pipe to be sure it was clear. It should be noted that even without the diffuser grating, the end of the pipe is still prone to clogging with debris because the vertical grating is positioned only a few inches from it.

(4) The 20" butterfly valve was removed from the middle diffuser line by cutting the flange bolts on the valve and pipe coupling. The valve was then placed on the deck near the fishway pump. After valve removal, the plugs in the gravity feed lines were withdrawn and water was allowed to flow into the constant head tank. As the tank filled up, it was observed that water flowed easily from the morning glory weir through the middle diffuser line and rushed into the valve pit. As the valve pit filled up, it was observed that water then flowed through the remainder of the middle line and rushed into pool 4 which up until that time had still been dewatered. Since there was no significant blockage at the valve, it appears that the debris at the end of the pipe was what caused the blockage in the middle diffuser line. The line is now clear.

(5) Inspection of the butterfly valve took place on 9 December. The valve was found to be in reasonably good condition with moderate rust on all steel and cast iron surfaces. (See Figure 5.) The rubber seat and monel disc sealing ring are in good condition. However, rust buildup from the cast iron valve disc has obscured the sealing ring bolts and may at some point interfere with the sealing ring surface. The valve operator turned easily throughout its entire range. When closed, the valve appeared to seal in spite of moderate trash and debris accumulation around the shaft. (Note that it sealed well enough to keep water from flowing back into the constant head tank when the fish bays were full.)

g. FLOATING WEIR

The floating weir was removed from its slot in late September and placed on the deck in front of the pumping station. Inspection of the weir took place on 8 October and the weir was pressure tested with nitrogen on 23 December. Although the weir had sunk to the bottom of the slot and was reported to be jammed, it was easily removed. The weir appeared to be in good condition with moderate corrosion and barnacle encrustation. (See Figures 6, 7, & 8.) Most of the barnacles were located near the top of the weir around the fish passage opening. The wheels all turned freely. Some of the wheel hardware was loose. Pressure testing of the upper portion of the weir revealed no leaks present with the exception of the rubber gasket at the fill pipe connection. The lower portion of the weir was not tested as

there are no connections on it.

h. FLOATING WEIR SLOTS

The floating weir slots were inspected by Daylor Consulting Group on 30 September and found to be in very good condition.

i. HARBOR END STOP LOG AND GUIDES

The 1" thick fiberglass stop log is in good condition. The remaining stop log guides and the area around the missing stop log guides were inspected by Daylor Consulting Group on 30 September. It was found that instead of being strap anchored to the concrete as called for in the original design, the guides had been bolted to the concrete with small diameter carbon steel bolts. These had corroded away, causing the guides to fall off. Condition of the concrete in the area of the missing guides was found to be good with some localized spalling around the corroded bolts.

j. BASIN END STOP LOG

According to the original drawings EP-20 and EP-21, the basin end stop log is identical to the stop logs for the high and low sluice gates. These are stored outside on the deck near the fishway. The fishway stop log is supposed to be inserted in the slot which holds the bar rack for the pump wet well. Rough measurements of the slot and the existing stop logs indicates that they should fit.

k. CONCRETE AND STRUCTURAL FEATURES

Non-submerged concrete and structural features of the fish passage facility were inspected on 4 December and found to be in good condition.

l. LOG BOOM

Although the condition of the log boom is fair to good, it has been observed that some large pieces of wood have evidently gotten past it and entered the fishway. Such items may be so waterlogged that they float below the surface and the log boom is unable to stop them. However, it has also been reported that vandals routinely throw large debris into the fishway in an attempt to block the fish from swimming through so that they can be more easily caught at the entrance.

m. GENERAL

The constant head tank and fishway bays are all filled with at least a foot of silt and small debris. Large boards were seen in several of the fishway bays. The opening in the false weir is partially clogged with debris.

3. RECOMMENDATIONS

Recommendations made below are made with the intention of fully restoring the fish passage so that it can function as originally designed. If only partial restoration is desired (i.e., operation only in the gravity flow mode), delete recommendations and costs for repairing pump and motor and for automatic pump controls. Additional costs associated with this option, such as capping the pump discharge pipes and installing a permanent barrier between bays 17 and 18 would probably be under $1000. Estimated costs are summarized in Table D-1.

Since fish have been observed migrating through the navigation locks during boat lockages, it has been suggested that operation of the locks be modified to enhance fish passage through the entire facility. Modifications would include increasing the number of daily lockages during times of peak migration, and lengthening the time that the locks remain open. Whatever locking protocols are recommended for the final report, consideration must be given to their effects on pedestrian traffic across the locks. The MDC was provided with a working system of automatic safety gates to prevent pedestrians from crossing the locks during lock operations. Due to vandalism and lack of maintenance by the MDC, the system is no longer functioning. The MDC is entirely responsible for maintaining this system; therefore, we believe that although the system definitely needs to be repaired, the costs to repair it should not be included in the cost of rehabilitating the fishway.

Note that many of the problems associated with the fishway appear to have been caused by lack of maintenance and excessive buildup of trash. Section V of the operating manual for the Charles River Dam lists recommended maintenance procedures and intervals.

These include weekly cleaning of the screen on the pump intake, daily cleaning of the fishway pools and yearly dewatering and thorough cleaning of the fishway. If these procedures are not followed by the MDC, the condition of the fishway will quickly deteriorate. In addition, as part of the restoration, we would recommend that after the repair work has been completed and the fishway is operational, fish migration through the entire lock and dam facility should be monitored for at least a year to determine if the fishway is passing significant numbers of fish.

a. Rebuild fishway pump. The manufacturer estimates that repair of the new pump would cost only 60% as much as a new pump. Impeller, shaft, discharge head, motor base plate and column all appear to be reusable. Column, base plate and discharge head require sand blasting and repainting, shaft and impeller must be checked for straightness and balance. Replace suction bell, diffuser, shaft enclosing tube and all minor parts such as couplings, bearings, gaskets, seals, fasteners. Diffuser should be replaced with Ni Resist instead of cast iron.

b. Replace motor. Existing motor has been sent out for repair twice and is no longer

worth repairing.

c. Adjust wedges on fishway sluice gate as recommended by Metcalf & Eddy in their 27 November 1991 report.

d. Replace automatic gate and pump level controls. New level sensors (one at the basin and one at the harbor), and a differentiating control panel will be required. In addition, the new pump motor will need new motor controls and proper motor protection to prevent recurrence of the motor burn out. Replace pressure gages on pump discharge lines.

e. Provide new 1/4" mesh stainless steel screen for pump intake wet well. Pull wetwell trash rack, clean, scrape and paint as necessary.

f. Gravity flow lines and flap valves appear to be performing their function properly and do not require any work.

g. Diffuser lines now appear to be clear. Pull all racks at ends of diffuser lines. Thoroughly clean racks. Jet clean pipes again. Reinstall racks. Do not reinstall gratings on ends of pipes. Butterfly valves appear to be performing their function properly and do not require any work.

h. The leak in the floating weir fill pipe connection should be repaired. Loose or missing wheel hardware should be replaced. Floating weir slots should be thoroughly cleaned as recommended by Daylor Consulting Group.

i. Underwater concrete repairs should be made to the damaged areas around the harbor entrance to the fishway as described by Daylor Consulting Group in their report. No other structural repairs are necessary at this time.

j. Harbor side stop log guides should be repaired and reinstalled as recommended by Daylor Consulting Group

k. The entire fish passage facility, including the pump wet well and constant head tank should be completely dewatered and cleaned of all silt and debris.

l. Design and build a barrier which will prevent fish from entering pools 18-29 during gravity flow operation when the pump is not operating.

m. Investigate the possibility and desirablilty of replacing the existing log boom with a more effective barrier. Such a barrier might extend several feet below the surface in order to stop large submerged debris. If this type of barrier were available, its effect on river flow and fish passage would have to be studied in detail. Estimated cost listed in Table I below

is based on replacing the existing log boom with a new boom of the same design. A new log boom designed to extend below the surface, might cost two or three times as much when additional design, study and material costs are taken into account.

TABLE D-1
COST ESTIMATES FOR RESTORATION OF FISH PASSAGE FACILITY *

	ITEM	COST
1.	Repair pump & reinstall	$35,000
2.	Replace motor	40,000
3.	Adjust sluice gate wedges	1,000
4.	Replace pump and gate controls	20,000
5.	Provide new S.S. screen	4,000
6.	Clean trash rack	2,000
7.	Repair floating weir & reinstall	5,500
8.	Provide barrier at bay 17	2,000
9.	Clean and repair underwater concrete and floating weir slots and repair and reinstall harbor stop log guides	11,000
10.	Dewater fishway	4,200
11.	Clean diffuser gratings	2,000
12.	Jet clean diffuser pipes	2,000
13.	Clean silt and debris from pump wet well, constant head tank, and fish bays.	4,000
14.	Replace log boom	$13,000
SUBTOTAL (Items 1 through 14)		$145,700
Prime Contractor Markup		$31,328
	SUBTOTAL	$177,028
Construction Contingency (Use 25%)		$44,257
SUBTOTAL		$221,285
Engineering and Design		$40,000
Supervision and Administration		$26,500
TOTAL FIRST COST		$287,785

* Note: See Feasibility Estimate report dated 3 March 1992 (attached) for further cost breakdown.

FIGURE 1. Fishway pump outer casing and shaft enclosing tube.

FIGURE 2. Fishway pump impeller.

FIGURE 3. Fishway pump diffuser section.

FIGURE 4. Fishway pump suction bell & lower bearing support.

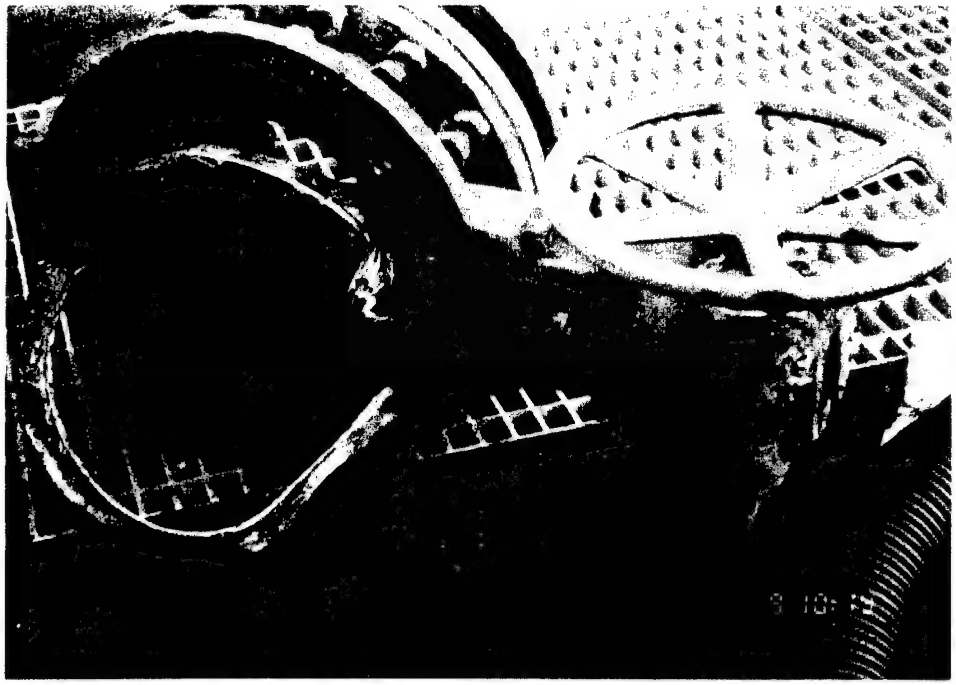

FIGURE 5. Butterfly valve from 20" diffuser line.

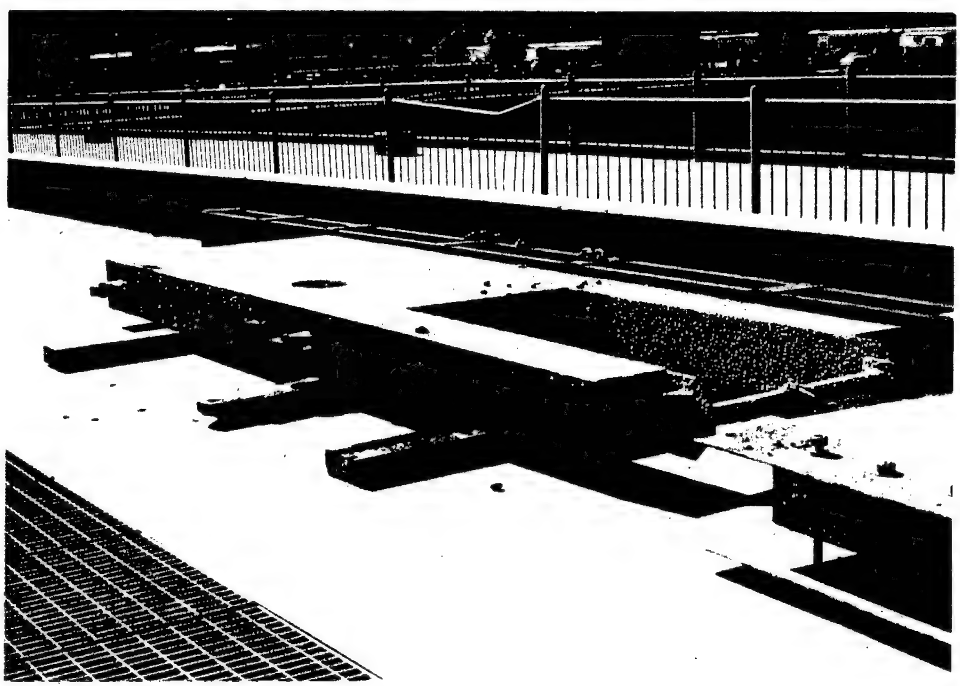

FIGURE 6. Floating weir, upper section.

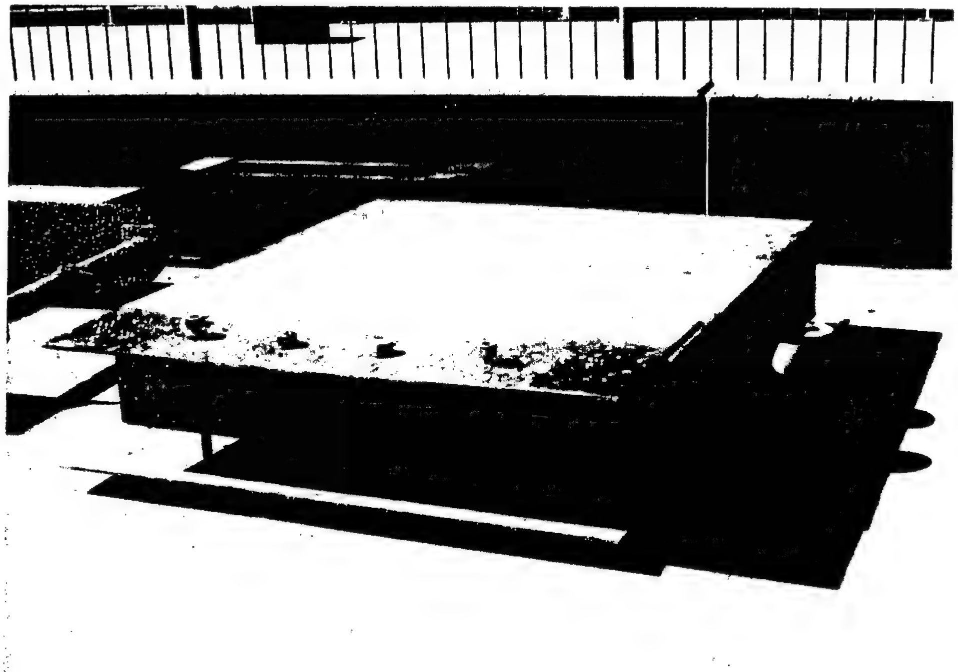

FIGURE 7. Floating weir, lower section.

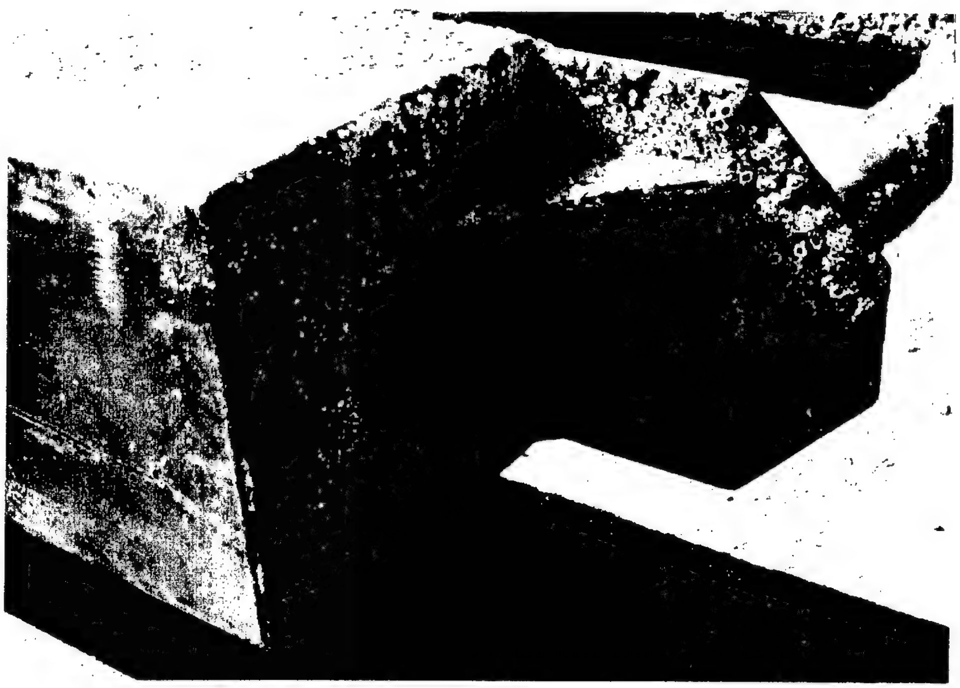

FIGURE 8. Floating weir, fill connection.

Restoration of Fish Passage
Facility
Charles River Dam
Boston, Massachusetts

Date: 03/03/92
Est Construction Time: 15 Days

M C A C E S G O L D E D I T I O N

Release 5.01E

The project consists of repairing and reinstalling a fishway pump, improving debris control practices, and minor repairs and modifications to other components. Repairs to the existing fishway pump would consist of rebuilding pump components, replacing the motor, and replacing automatic gate and pump level controls. Improving debris control components would include installing a new screen at the pumpwell, cleaning the trash rack and diffuser gratings and replacing the existing log boom. Minor repairs to other components would incluide, sealing and reinstalling the floating weir, reinstalling stop log guides and installing a barrier in fish bay 17.

SUMMARY REPORTS SUMMARY PAGE

DETAILED ESTIMATE DETAIL PAGE

No Backup Reports...

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** PROJECT OWNER SUMMARY - LEVEL 1 **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	OTHER	TOTAL COST	UNIT
A Restoration of Fish Passage		177,028	44,257	0	0	221,285	
Restoration of Fish Passage		177,028	44,257	0	0	221,285	

		QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	OTHER	TOTAL COST	UNIT
A	Restoration of Fish Passage							
A/ 1	Repair Pump and Reinstall		42,526	10,631	0	0	53,157	
A/ 2	Replace Motor		48,601	12,150	0	0	60,751	
A/ 3	Adjust Sluice Gate Wedges		1,215	304	0	0	1,519	
A/ 4	Replace Pump and Gate Controls		24,300	6,075	0	0	30,375	
A/ 5	Provide New SS Screen		4,860	1,215	0	0	6,075	
A/ 6	Clean Trash Rack		2,430	608	0	0	3,038	
A/ 7	Repair Floating Weir & Reinstall		6,683	1,671	0	0	8,353	
A/ 8	Provide Barrier at Bay 17		2,430	608	0	0	3,038	
A/ 9	Clean and Repair Slots & Guides		13,365	3,341	0	0	16,706	
A/10	Dewater Fishway		5,103	1,276	0	0	6,379	
A/11	Clean Diffuser Gratings		2,430	608	0	0	3,038	
A/12	Clean Diffuser Pipes		2,430	608	0	0	3,038	
A/13	Clean Well, Tank and Fish Bays		4,860	1,215	0	0	6,075	
A/14	Replace Log Boom		15,795	3,949	0	0	19,744	
	Restoration of Fish Passage		177,028	44,257	0	0	221,285	
	Restoration of Fish Passage		177,028	44,257	0	0	221,285	

** PROJECT INDIRECT SUMMARY - LEVEL 1 **

	QUANTY UOM	DIRECT	DISTRIBU	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
A Restoration of Fish Passage		145,700	0	10,199	7,795	11,581	1,753	177,028	
Restoration of Fish Passage		145,700	0	10,199	7,795	11,581	1,753	177,028	
Contingency								44,257	
TOTAL INCL OWNER COSTS								221,285	

** PROJECT INDIRECT SUMMARY - LEVEL 2 **

		QUANTY UOM	DIRECT	DISTRIBU	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
A	Restoration of Fish Passage									
A/ 1	Repair Pump and Reinstall		35,000	0	2,450	1,873	2,782	421	42,526	
A/ 2	Replace Motor		40,000	0	2,800	2,140	3,180	481	48,601	
A/ 3	Adjust Sluice Gate Wedges		1,000	0	70	54	79	12	1,215	
A/ 4	Replace Pump and Gate Contr		20,000	0	1,400	1,070	1,590	241	24,300	
A/ 5	Provide New SS Screen		4,000	0	280	214	318	48	4,860	
A/ 6	Clean Trash Rack		2,000	0	140	107	159	24	2,430	
A/ 7	Repair Floating Weir & Rein		5,500	0	385	294	437	66	6,683	
A/ 8	Provide Barrier at Bay 17		2,000	0	140	107	159	24	2,430	
A/ 9	Clean and Repair Slots & Gu		11,000	0	770	589	874	132	13,365	
A/10	Dewater Fishway		4,200	0	294	225	334	51	5,103	
A/11	Clean Diffuser Gratings		2,000	0	140	107	159	24	2,430	
A/12	Clean Diffuser Pipes		2,000	0	140	107	159	24	2,430	
A/13	Clean Well, Tank and Fish B		4,000	0	280	214	318	48	4,860	
A/14	Replace Log Boom		13,000	0	910	696	1,033	156	15,795	
	Restoration of Fish Passage		145,700	0	10,199	7,795	11,581	1,753	177,028	
	Restoration of Fish Passage		145,700	0	10,199	7,795	11,581	1,753	177,028	
	Contingency								44,257	
	TOTAL INCL OWNER COSTS								221,285	

** PROJECT DIRECT SUMMARY - LEVEL 1 **

	QUANTITY UOM	LABOR	EQUIPMNT	MATERIAL	SUPPLIES	TOTAL COST	UNIT COST
A Restoration of Fish Passage		79,110	5,300	61,290	0	145,700	
Restoration of Fish Passage		79,110	5,300	61,290	0	145,700	
Overhead						10,199	
SUBTOTAL						155,899	
Home Office Percent						7,795	
SUBTOTAL						163,694	
Profit						11,581	
SUBTOTAL						175,275	
Bond						1,753	
TOTAL INCL INDIRECTS						177,028	
Contingency						44,257	
TOTAL INCL OWNER COSTS						221,285	

		QUANTITY UOM	LABOR	EQUIPMNT	MATERIAL	SUPPLIES	TOTAL COST	UNIT COST
A	Restoration of Fish Passage							
A/ 1	Repair Pump and Reinstall		3,000	1,300	30,700	0	35,000	
A/ 2	Replace Motor		17,210	0	22,790	0	40,000	
A/ 3	Adjust Sluice Gate Wedges		1,000	0	0	0	1,000	
A/ 4	Replace Pump and Gate Controls		20,000	0	0	0	20,000	
A/ 5	Provide New SS Screen		1,200	0	2,800	0	4,000	
A/ 6	Clean Trash Rack		2,000	0	0	0	2,000	
A/ 7	Repair Floating Weir & Reinstall		4,700	800	0	0	5,500	
A/ 8	Provide Barrier at Bay 17		2,000	0	0	0	2,000	
A/ 9	Clean and Repair Slots & Guides		11,000	0	0	0	11,000	
A/10	Dewater Fishway		4,000	200	0	0	4,200	
A/11	Clean Diffuser Gratings		2,000	0	0	0	2,000	
A/12	Clean Diffuser Pipes		2,000	0	0	0	2,000	
A/13	Clean Well, Tank and Fish Bays		4,000	0	0	0	4,000	
A/14	Replace Log Boom		5,000	3,000	5,000	0	13,000	
	Restoration of Fish Passage		79,110	5,300	61,290	0	145,700	
	Restoration of Fish Passage		79,110	5,300	61,290	0	145,700	
	Overhead						10,199	
	SUBTOTAL						155,899	
	Home Office Percent						7,795	
	SUBTOTAL						163,694	
	Profit						11,581	
	SUBTOTAL						175,275	
	Bond						1,753	
	TOTAL INCL INDIRECTS						177,028	
	Contingency						44,257	
	TOTAL INCL OWNER COSTS						221,285	

Repair Pump and Reinstall	QUANTITY UOM	LABOR	EQUIPMNT	MATERIAL	SUPPLIES	TOTAL COST	UNIT COST
Repair Pump and Reinstall							
Repair Pump and Reinstall		3,000	1,300	30,700	0	35,000	
Replace Motor							
Replace Motor		17,210	0	22,790	0	40,000	
Adjust Sluice Gate Wedges							
Adjust Sluice Gate Wedges		1,000	0	0	0	1,000	
Replace Pump and Gate Controls							
Replace Pump and Gate Controls		20,000	0	0	0	20,000	
Provide New SS Screen							
Provide New SS Screen		1,200	0	2,800	0	4,000	
Clean Trash Rack							
Clean Trash Rack		2,000	0	0	0	2,000	
Repair Floating Weir & Reinstall							
Repair Floating Weir & Reinstall		4,700	800	0	0	5,500	
Provide Barrier at Bay 17							
Provide Barrier at Bay 17		2,000	0	0	0	2,000	
Clean and Repair Slots & Guides							
Clean and Repair Slots & Guides		11,000	0	0	0	11,000	
Dewater Fishway							
Dewater Fishway		4,000	200	0	0	4,200	
Clean Diffuser Gratings							
Clean Diffuser Gratings		2,000	0	0	0	2,000	
Clean Diffuser Pipes							
Clean Diffuser Pipes		2,000	0	0	0	2,000	
Clean Well, Tank and Fish Bays							
Clean Well, Tank and Fish Bays		4,000	0	0	0	4,000	
Replace Log Boom							
Replace Log Boom		5,000	3,000	5,000	0	13,000	
Restoration of Fish Passage		79,110	5,300	61,290	0	145,700	
Restoration of Fish Passage		79,110	5,300	61,290	0	145,700	

No errors detected ....

*** END OF ERROR REPORT ***

** PROJECT SETTINGS **

ESTIMATE TYPE : C-CACES Mode (with Auto)

SALES TAX : 0.00%

PROJECT DIRECT COST COLUMNS

Col type	L	E	M	U	X
Rep Width	12	12	12	12	0
Title	LABOR	EQUIPMNT	MATERIAL	SUPPLIES	(Unused)

PROJECT INDIRECT COST COLUMNS

Col type	U	O	U	P	B
Rep Width	10	10	10	10	10
Title	DISTRIBU	OVERHEAD	HOME OFC	PROFIT	BOND

PROJECT OWNER COST COLUMNS

Col type	U	E	U	X	X
Rep Width	12	12	12	0	0
Title	CONTINGN	ESCALATN	OTHER	(Unused)	(Unused)

PROJECT BREAKDOWN

PROJECT ID	Length	Trail Sep	Level Title
Level 1 ID :	1	/	Contract
Level 2 ID :	2	.	Bid Item
Level 3 ID :	2	.	Assembly
Level 4 ID :	0	/	Element
Level 5 ID :	0	.	Bid Item
Level 6 ID :	0	.	Assembly

Owner Cost Level : 2

** PROJECT SETTINGS **

DETAIL REPORT FORMATTING

PAGE OPTIONS
Page Break Levels : 2
Table of Contents Levels : 2

		0 1 2 3 4 5 6 7
ROW OPTIONS	Print Titles at Levels :	N Y Y N N N
	Print Totals at Levels :	Y Y N N N N
	Print Notes at Levels :	Y Y Y Y Y Y Y Y
	Print Unit Cost Row :	N
	Print Page Footer :	Y
	Show Cost Codes :	N
COLUMNS OPTIONS	Print Crew Id :	N
	Crew Output :	N
	Unit Cost :	Y
UPB TITLES	No. of Levels to Print :	0
	Bracket Titles With :	N N
	Include titles Notes :	N

OTHER REPORT FORMATTING

COLUMN TITLES FOR SUMMARY REPORTS

Column 1 DISTRIBU :	Distribution
Column 2 OVERHEAD :	Overhead
Column 3 HOME OFC :	Home Office Percent
Column 4 PROFIT :	Profit
Column 5 BOND :	Bond
Column 1 CONTINGN :	Contingency
Column 2 ESCALATN :	Escalation
Column 3 OTHER :	Other
Column 4 (Unused) :	(Unused)
Column 5 (Unused) :	(Unused)

STANDARD COLUMN WIDTHS

Quantity Columns :	10
Total cost Columns :	12
Unit Cost Columns :	10

** PROJECT SETTINGS **

REPORT SELECTION

Project Settings : Y
Contractor Settings : N Measurement Units : ORG
Link Listing : N

	REPORT FORMAT TYPE			FOR LEVEL (S)						
	Direct	Indirect	Owner	0	1	2	3	4	5	6
Detail :	Y									
Project :	Y	Y	Y		Y	Y	N	N	N	N
Contractor :	N	N		N	N	N	N	N	N	N
Division :	N	N	N	N	N	N	N	N	N	N
System :	N	N	N	N	N	N	N	N	N	N
Work Cat :	N	N	N	N	N	N	N	N	N	N
Crew :	N			N	N	N	N	N	N	N
Labor :	N									
Equipment :	N									

** OWNER SETTINGS **

		AMOUNT	PERCENT	*ESCALATN DATE* BEGIN	END	*ESCALATN INDEX* BEGIN	END
Project Information Record							
A Restoration of Fish Passage							
A/ 1 Repair Pump and Reinstall							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/ 2 Replace Motor							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/ 3 Adjust Sluice Gate Wedges							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/ 4 Replace Pump and Gate Controls							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/ 5 Provide New SS Screen							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/ 6 Clean Trash Rack							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/ 7 Repair Floating Weir & Reinstall							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/ 8 Provide Barrier at Bay 17							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/ 9 Clean and Repair Slots & Guides							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				

** OWNER SETTINGS **

		AMOUNT	PERCENT	*ESCALATN DATE* BEGIN	END	*ESCALATN INDEX* BEGIN	END
A/10 Dewater Fishway							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/11 Clean Diffuser Gratings							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/12 Clean Diffuser Pipes							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/13 Clean Well, Tank and Fish Bays							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				
A/14 Replace Log Boom							
	Contingency	P	25.00				
	Escalation	P	0.00				
	Other	P	0.00				

APPENDIX E

FISH PASSAGE DETERMINATIONS

TABLE OF CONTENTS

APPENDIX E

FISH PASSAGE HOUR DETERMINATIONS

I. FISH LADDER

<u>Fish Passage at the Ladder</u>

The fish ladder provides upstream fish passage for alewife, blueback herring and shad. These species primarily migrate between sunrise and sunset. Migration seasons may overlap but encompass the period from 1 April to 30 June, an approximate 13 week period. During the 13 week period, the length of day varies from about 12 hours 45 minutes to 15 hours 15 minutes with an average daytime period of about 14 hours 25 minutes.

The time of tide cycle also varies with an average time of cycle of about 12 hours and 25 minutes. During a tide cycle the water level in the harbor is lower than the basin water level about 60% of the tidal cycle or about 7.5 hours. However, effective passage time conditions occur for about 55% of the tidal cycle (during gravity flow conditions) because velocities at the harbor entrance must develop to some appreciable amount.

Determinations of fish passage time are based on the occurrence of effective entrance velocities conditions. Information provided by the <u>Fisheries Handbook of Engineering Requirements and Biological Criteria,</u> US Army Corps of Engineers, indicate that the minimum velocity of 4 feet per second needs to occur at the harbor entrance before effective passage takes place.

<u>Passage Hour Determinations</u>

Full Restoration

Under full restoration a fishway pump would be available to provide flow through the fish ladder during high tide conditions. The fishway pump would be operated 45% of the tide cycle time and gravity flow would occur 55% of the time. The opportunity for fish to use the facility would be continuous each day. Cumulative passage time is:

13 weeks X 7 days/week X (14 hours 25 minutes)/day = <u>Say 1300 hours</u>

Partial Restoration

Partial restoration would be tidal dependent and occur 55% of a tidal cycle. Since the tidal cycle is time is less than a full day length, as much as two additional passage hours could

occur as a result of a second tide. The second tide event would occur about one-half of the days during the 13 week period. Cumulative passage time is:

13 weeks X 7 days/week X{[(12 hours 25 minutes)(55%)]/day + 2 hours X 1/2season} = <u>Say 700 hours</u>

<u>Existing Conditions</u>

Existing conditions significantly limit the development of effective velocities at the harbor entrance. These conditions include the sunken weir and debris blockage. To determine the period of time when effective velocities occur at the harbor entrance, a hydraulic evaluation was made of the flow conditions at Mean Spring Low Water (MSLW). Information provided in Appendix B was used to determine flows at the harbor entrance. The evaluation first determined the flow under ideal conditions and then adjusted the flow based on debris accumulation. The evaluation assumed a fully blocked diffuser pipe to typify existing debris problems. (Field inspections observed significant amounts of debris throughout the system which included a partially blocked and fully blocked diffuser pipe.) Finally, the harbor entrance velocity was determined by dividing the flow by the cross sectional area.

Under ideal conditions the flow at the harbor entrance during mean spring low water is about 57.8 cubic feet per second (cfs). This flow is reduced to 47.7 cfs assuming one small diffuser pipe fully blocked. The cross sectional area is 13.2 feet and the velocity is about 3.6 fps at the weir. A harbor level increase of 0.1 foot would result in a velocity of 3.5 fps which would be the minimum allowable for effective conditions.

A review of tide tables indicated that tides at or below MSLW occur about 30 times between 1 April and 30 June. To complete the evaluation of existing conditions, it was assumed that an equivalent of one hour effective passage time would be available whenever these low water conditions occurred.

II. NAVIGATION LOCKS

<u>Boat Lockings and Passage Time</u>

An upstream boat locking procedure consists of opening the harbor gate, closing the gate, adjusting lockwater level, opening the basin gate and closing the basin gate. Each procedure lasts about 5 minutes. The harbor gate remains open about 1 to 2 minutes during which boats enter the lock. Closure of the harbor gate, lockwater adjustment, and basin gate opening takes between 1 to 3 minutes. The basin gate remains open about 1 to 2 minutes during which boats exit the lock.

Although a locking procedure takes about 5 minutes, fish passage time would be less due to travel time through the locks. To account for reduced opportunity, the time available

for fish to successfully enter the basin is considered to be equivalent to the time the harbor gate is opened, or about 1 to 2 minutes.

A downstream boat locking procedure is a reversed upstream procedure. Downstream procedures provide less opportunity for fish to gain access to the basin. A single downstream locking procedure prevents fish from entering the basin since the basin gates are opened and closed before the harbor gates are opened. Either double downstream locking procedures or frequent downstream locking procedures need to occur before credit may be taken for fish passage times.

Upstream Fish Migration Seasons and Periods

For analysis purposes consider the following migrations seasons and periods:

Smelt - From 15 March to 30 April anytime between sunset and sunrise.

Alewife and blueback herring - From 1 April to 31 May anytime between sunrise to sunset.

Shad - From 15 May to 30 June anytime between sunrise and sunset.

Passage Hour Determinations for Existing Conditions

Fish passage hour determinations for existing conditions are based on a review of 1989 and 1990 locking records maintained by MDC.

Smelt - Number of upstream boat lockings from 15 March to 30 April between sunset and sunrise is 55. Each procedure represents about 1.5 minutes of fish passage opportunity, say 1 to 2 hours.

Alewife and blueback herring - Number of equivalent upstream boat lockings from 1 April to 31 May between sunrise and sunset is 1200. Each procedure represents about 1.5 minutes of fish passage opportunity, say 25 to 40 hours.

Shad - Number of equivalent upstream boat lockings from 15 May to 30 June between sunrise and sunset is 1900. Each procedure represents about 1.5 minutes of fish passage opportunity, say 45 to 50 hours.

Passage Hour Determination for Locking Protocol Conditions

Locking protocol calls for hourly lockings when the harbor level is less than the basin level. The harbor level is less than the basin level about 7 hours of each 12 hour 25 minute tide cycle. Conservatively consider that the opportunity for fish passage is dependent upon the time of basin gate opening (10 minutes each hour) as opposed to harbor gate opening (30 minutes each hour).

Smelt - Number of lockings each day between sunset and sunrise is 7 and number of days is 46. Each procedure represents 10 minutes of fish passage opportunity or, 7 times per day X 46 days X 1/6 hours, <u>say 55 hours</u>.

Alewife and blueback herring - Number of lockings each day between sunrise and sunset is 7 and number of days is 61. Each procedure represents 10 minutes of fish passage opportunity or, 7 times per day X 61 days X 1/6 hours, <u>say 75 hours</u>.

Shad - Number of lockings each day between sunrise and sunset is 7 and number of days is 46. Each procedure represents 10 minutes of fish passage opportunity or, 7 times per day X 46 days X 1/6 hours, <u>say 55 hours</u>.